



PROYEK AKHIR TERAPAN - RC146599

MODIFIKASI DESAIN STRUKTUR JEMBATAN TOL PASURUAN-PROBOLINGGO STA 29+325 DENGAN STRUKTUR *CABLE-STAYED* BENTANG 144 METER

IMAM NAKHROWI
NRP. 1011141 0000028

Dosen Pembimbing I
Ir. Ibnu Pudji Rahardjo, MS
NIP. 19600105 198603 1 003

Dosen Pembimbing II
Ir. Chomaedhi, CES. Geo
NIP. 19550319 198403 1 001

PROGRAM STUDI DIPLOMA EMPAT TEKNIK SIPIL
DEPARTEMEN TEKNIK INFRASTRUKTUR SIPIL
FAKULTAS VOKASI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA 2018



APPLIED FINAL PROJECT- RC146599

DESIGN MODIFICATION STRUCTURE OF TOLL BRIDGE PASURUAN - PROBOLINGGO STA 29+325 WITH *CABLE-STAYED* STRUCTURE SPAN 144 METERS

IMAM NAKHROWI
NRP. 1011141 0000028

Supervisor 1
Ir. Ibnu Pudji Rahardjo, MS
NIP. 19600105 198603 1 003

Supervisor II
Ir. Chomaedhi, CES. Geo
NIP. 19550319 198403 1 001

CIVIL INFRASTRUCTURE ENGINEERING
FACULTY OF VOCATIONAL
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA 2018



PROYEK AKHIR TERAPAN - RC146599

**MODIFIKASI DESAIN STRUKTUR JEMBATAN
TOL PASURUAN-PROBOLINGGO STA 29+325
DENGAN STRUKTUR *CABLE-STAYED*
BENTANG 144 METER**

IMAM NAKHROWI
NRP. 1011141 0000028

Dosen Pembimbing I
Ir. Ibnu Pudji Rahardjo, MS
NIP. 19600105 198603 1 003

Dosen Pembimbing II
Ir. Chomaedhi, CES. Geo
NIP. 19550319 198403 1 001

PROGRAM STUDI DIPLOMA EMPAT TEKNIK SIPIL
DEPARTEMEN TEKNIK INFRASTRUKTUR SIPIL
FAKULTAS VOKASI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA 2018



APPLIED FINAL PROJECT- RC146599

**DESIGN MODIFICATION STRUCTURE OF TOLL
BRIDGE PASURUAN - PROBOLINGGO STA
29+325 WITH *CABLE-STAYED* STRUCTURE
SPAN 144 METERS**

**IMAM NAKHROWI
NRP. 1011141 0000028**

**Supervisor 1
Ir. Ibnu Pudji Rahardjo, MS
NIP. 19600105 198603 1 003**

**Supervisor II
Ir. Chomaedhi, CES. Geo
NIP. 19550319 198403 1 001**

**CIVIL INFRASTRUCTURE ENGINEERING
FACULTY OF VOCATIONAL
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
SURABAYA 2018**

LEMBAR PENGESAHAN
MODIFIKASI DESAIN STRUKTUR JEMBATAN TOL
PASURUAN – PROBOLINGGO STA 29+325 DENGAN
STRUKTUR CABLE-STAYED BENTANG 144 METER

TUGAS AKHIR TERAPAN

Diajukan untuk Memenuhi Salah Satu Syarat Memperoleh Gelar
Sarjana Sains Terapan

Pada

Program Studi Diploma IV Teknik Infrastruktur Sipil

Fakultas Vokasi

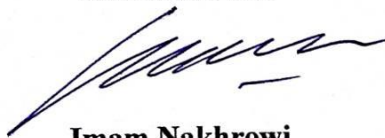
Institut Teknologi Sepuluh Nopember

Surabaya

Surabaya, 20 Juli 2018

Disusun Oleh :

MAHASISWA



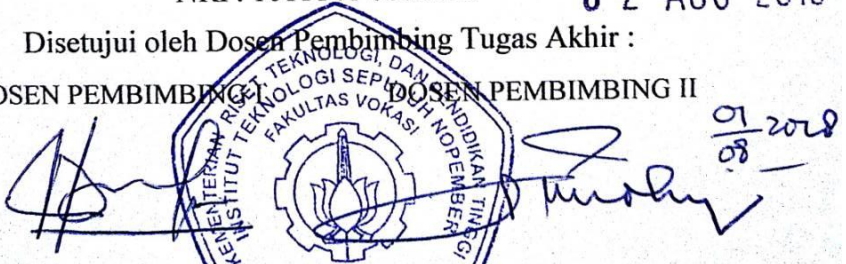
Imam Nakhrowi

NRP. 1011141 0000028

02 AUG 2018

Disetujui oleh Dosen Pembimbing Tugas Akhir :

DOSEN PEMBIMBING I DOSEN PEMBIMBING II



Ir. Ibnu Pudji Rahardjo, MS **Ir. Chomaedhi, CES. Geo**

NIP. 19600105 198603 1 003

NIP. 19550319 198403 1 001



BERITA ACARA
TUGAS AKHIR TERAPAN
PROGRAM STUDI DIPLOMA EMPAT TEKNIK SIPIL
DEPARTEMEN TEKNIK INFRASTRUKTUR SIPIL
FAKULTAS VOKASI ITS

No. Agenda :
041523/IT2.VI.8.1/PP.05.02/2018

Tanggal : 20 Juli 2018

Judul Tugas Akhir Terapan	Modifikasi Perencanaan Struktur Jembatan Tol Pasuruan Probolinggo STA 29+325 Dengan Struktur Cable Stayed bentang 144 M		
Nama Mahasiswa	Imam Nakhrowi	NRP	1101410000028
Dosen Pembimbing 1	Ir. Ibnu Pudji Raharjo, MS. NIP 19600105 198603 1 003	Tanda tangan	
Dosen Pembimbing 2	Ir. Chomaedhi, CES.Geo. NIP 19550319 198403 1 001	Tanda tangan	

URAIAN REVISI	Dosen Penguji
.....	Ir. Ibnu Pudji Raharjo, MS. NIP 19600105 198603 1 003
.....	Ir. Chomaedhi, CES.Geo. NIP 19550319 198403 1 001
1. Gambar No 13 2. Gambar anker - ? 3. Rencanakan jembatan ? 4. Bentasan masala → abutment ✓	Ir. Agung Bp, M.Eng PhD NIP 19620328 198803 1 001
1. Gambar → Satva & Dinamika 2. Tabel pemilihan dasar desain	Amalia Firdaus Mawardi, ST., MT NIP 19770218 200501 2 002

PERSETUJUAN HASIL REVISI			
Dosen Penguji 1	Dosen Penguji 2	Dosen Penguji 3	Dosen Penguji 4
Ir. Ibnu Pudji Raharjo, MS. NIP 19600105 198603 1 003	Ir. Chomaedhi, CES.Geo. NIP 19550319 198403 1 001	Ir. Agung Bp, M.Eng PhD NIP 19620328 198803 1 001	Amalia Firdaus Mawardi, ST., MT NIP 19770218 200501 2 002

Persetujuan Dosen Pembimbing Untuk Penjilidan Buku Laporan Tugas Akhir Terapan	Dosen Pembimbing 1	Dosen Pembimbing 2
	Ir. Ibnu Pudji Raharjo, MS. NIP 19600105 198603 1 003	Ir. Chomaedhi, CES.Geo. NIP 19550319 198403 1 001



KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER

FAKULTAS VOKASI
 DEPARTEMEN TEKNIK INFRASTRUKTUR SIPIL
 Kampus ITS, Jl. Menur 127 Surabaya 60116
 Telp. 031-5947637 Fax. 031-5938025
<http://www.diplomasipil-its.ac.id>

ASISTENSI TUGAS AKHIR TERAPAN

Nama : 1 Imam Nakhrawi **2**
NRP : 1 0111910000 28 **2**
Judul Tugas Akhir : Modifikasi Perencanaan Struktur Jembatan Tol Pasuruan-Probolinggo
 STA. 29+328 Dengan Struktur Cable-Stayed Bentang 1019 Meter
 1. Ir. Ibnu Rudi Rahardjo, MS
Dosen Pembimbing : 2 Ir. Chamaedhi, CES, Geo

No	Tanggal	Tugas / Materi yang dibahas	Tanda tangan	Keterangan		
1.	23-02-2018	Gambar dibuat yang riil				
		- Sesuai dengan perencanaan				
		- layout pile cap diubah menjadi dua terpisah		B	C	K
				<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	07-03-2018	- Gunakan tipe kabel paralel				
		- Gunakan product untuk dimensi				
		gelagar memanjang dari melintang		B	C	K
		- Balok melintang dihitung komposit		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		dan dipasang bondok				
3.	28-03-2018	- Sambungan baut gunakan				
		High Tension Bolt		B	C	K
		- Gunakan spek product untuk HTB		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		- Baut sambungan tidak boleh				
4.	17-04-2018	- cat kecatan galvaneis				
		- Perhitungan tulangan pelat		B	C	K
		gunakan bondok untuk tul. tumpuan		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		- Tidak perlu tul. bagi				
5.	23-04-2018	- Di lower beam pylon diberi				
		damper		B	C	K
		- Pelat dihitung one way		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
		slab				

Ket. :
 B = Lebih cepat dari jadwal
 C = Sesuai dengan jadwal
 K = Tertelat dari jadwal

Chamaedhi



KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER

FAKULTAS VOKASI
DEPARTEMEN TEKNIK INFRASTRUKTUR SIPIL
Kampus ITS, Jl. Menur 127 Surabaya 60116
Telp. 031-5947637 Fax. 031-5938025
<http://www.sipil.itb.ac.id>

ASISTENSI TUGAS AKHIR TERAPAN

Nama : 1 2
NRP : 1 2
Judul Tugas Akhir :

Dosen Pembimbing :

No	Tanggal	Tugas / Materi yang dibahas	Tanda tangan	Keterangan		
6	09-05-2018	- Box girder dihitung aerodinamisnya				
		- Beban mati tambahan dimasukkan ke balok menyangga		<input type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> K
		- Perhitungan gaya gesekan		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	28-05-2018	- peratran tahun 2016				
		- Hitung daya dukung pondasi		<input type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> K
		- Usahakan dek sedikit naik saat ereksi		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	05-06-2018	- Core spek Form traveler				
		- Hitung juga maintenance kabel		<input type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> K
		- Hitung beban agar jembatan lurus kembali		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> K
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				<input type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> K
				<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Ket.
B = Lebih cepat dari jadwal
C = Sesuai dengan jadwal
K = Tertambat dari jadwal

Cue

MODIFIKASI DESAIN STRUKTUR JEMBATAN TOL PASURUAN – PROBOLINGGO STA 29+325 DENGAN STRUKTUR CABLE-STAYED BENTANG 144 METER

Nama Mahasiswa : Imam Nakhrowi
NRP : 1011141 0000028
Departemen : Teknik Infrastruktur Sipil- FV- ITS
**Dosen Pembimbing : Ir. Ibnu Pudji Rahardjo, MS
Ir. Chomaedhi, CES. Geo**

Abstrak

Dalam tugas akhir ini akan direncanakan struktur jembatan menggunakan struktur cable-stayed di Tol Pasuruan-Probolinggo Sta. 29+325 dengan bentang 144 meter. Konfigurasi kabel jembatan menggunakan fan pattern dengan posisi kabel double plane. Jembatan memiliki lebar lantai kendaraan 20,5 m.

Adapun hasil dari perencanaan ini adalah bangunan atas dan bangunan bawah. Dalam pembahasan ini lantai kendaraan didesain berupa pelat beton dengan steeldeck, sedang gelagar menggunakan balok komposit dan box baja non komposit. Kemudian stay cable tersusun atas 7-wire strand berdiameter 15,2 mm. Sedangkan pylon didesain dengan menggunakan beton bertulang. Untuk permodelan struktur utama menggunakan analisa dengan pembebanan statis dan dinamis, selanjutnya analisa metode pelaksanaan menggunakan metode demolishing procedure melalui backward solution dengan program bantu MIDAS Civil. Jembatan juga dianalisa stabilitas aerodinamis yang meliputi control terhadap frekuensi alami, efek flutter, dan vortex-shedding.

Kata kunci : cable stayed, fan pattern, double plane system, box girder

(halaman ini sengaja dikosongkan)

DESIGN MODIFICATION STRUCTURE OF TOLL BRIDGE PASURUAN-PROBOLINGGO STA 29+325 WITH CABLE-STAYED STRUCTURE SPAN 144 METERS

Name Student : Imam Nakhrowi
NRP : 1011141 0000028
Major : Teknik Infrastruktur Sipil- FV-ITS
Supervisor : Ir. Ibnu Pudji Rahardjo, MS
Ir. Chomaedhi, CES. Geo

Abstract

In this final project will be planned bridge structure using cable-stayed structure at toll Pasuruan-Probolinggo Sta. 29+325 with span of 144 meters. Bridge cable configuration using fan pattern with double plane cable position. The deck of bridge has width of 20,5m.

The result of this final project are upper and lower structure.in this design, the deck of bridge consist of concrete slab with steeldeck, the girder was using composite and non-composite steel box. Then stay cable is made up of 7-wire strand with diameter of 15.2 mm. while the pylon designed using reinforced concrete material. For the main structure using analysis with static and dynamic load. Staging analysis was using demolishing procedure method through backward solution using MIDAS Civil program. Then, the bridge also analyzed aerodynamic stability which include control of natural frequency, flutter effect, and also vortex shedding effect

Keywords : cable stayed, fan pattern, double plane system, box girder

(halaman ini sengaja dikosongkan)

KATA PENGANTAR

Segala puji bagi Allah Azza Wa Jalla, Rabb Semesta Alam, yang tiada Tuhan yang berhak disembah melainkan Dia, yang Maha Tinggi lagi Maha Perkasa. Atas rahmat dan karunia-Nya sehingga penulis dapat menyelesaikan Tugas Akhir Terapan dengan judul “Modifikasi Desain Struktur Jembatan Tol Pasuruan-Probolinggo Sta 29+325 dengan Struktur *Cable-stayed* Bentang 144 Meter”. Dalam penyusunan Tugas Akhir Terapan ini penulis menyadari masih terdapat kekurangan, maka dari itu kritik dan saran yang membangun sangat diharapkan demi kesempurnaan penyusunan Tugas Akhir Terapan ini. Dan tidak berlebihan kiranya bila penulis menyampaikan terima kasih kepada :

1. Teristimewa kedua orang tua penulis Bapak Iriyanto dan Ibu Sri Sukaesih.
2. Ir. Ibnu Pudji Rahardjo, MS dan Ir. Chomaedhi, CES. Geo selaku dosen pembimbing Tugas Akhir Terapan yang selalu memberi bimbingan, pengarahan, serta dukungan moril dan materiil.
3. Kepada adikku Khikmatul Munawaroh yang sedang mencari jati diri, semoga kita dapat menjadi kebanggaan orang tua.
4. Rekan-rekan mahasiswa serta seluruh pihak yang ikut membantu dan mendoakan kelancaran penusunan Tugas Akhir Terapan ini.

Penulis berharap Tugas Akhir Terapan ini dapat membawa manfaat bagi penulis sendiri maupun pihak lainnya. Akhirnya, meski telah diupayakan kesalahan tidak dapat dipisahkan dari penulisan Tugas Akhir ini, baik sengaja maupun tidak. Untuk itu dimohonkan maaf sebesar-besarnya.

Surabaya
Penulis,

Imam Nakhrowi

(halaman ini sengaja dikosongkan)

DAFTAR ISI

Abstrak	i
Abstract	iii
KATA PENGANTAR	v
DAFTAR ISI	vii
DAFTAR GAMBAR	xi
DAFTAR TABEL	xvii
BAB I PENDAHULUAN	1
1.1 Latar Belakang	1
1.2 Rumusan Masalah	2
1.3 Maksud dan Tujuan	2
1.4 Manfaat.....	3
1.5 Batasan Masalah.....	3
1.6 Peta Lokasi	4
BAB II TINJAUAN PUSTAKA	7
2.1 Umum.....	7
2.2 Komponen Struktur Jembatan Cable Stayed.....	7
2.2.1 Bangunan Atas	7
2.2.2 Bangunan Bawah.....	13
2.3 Pembebanan Jembatan	14
2.3.1 Beban Permanen.....	14
2.3.2 Beban Lalu Lintas	15
2.3.3 Aksi Lingkungan	17
2.3.4 Kombinasi Pembebanan	21
2.4 Analisa Dinamis Struktur	32
2.4.1 Frekuensi Alami	32
2.4.2 Perilaku Aerodinamis.....	33
2.4.3 Osilasi Gaya Akibat Pusaran Angin.....	34
2.4.4 Efek Flutter.....	37
2.5 Metode Pelaksanaan	39
BAB III METODOLOGI	41
3.1 Diagram Alir.....	41
3.2 Pengumpulan Data	43

3.3	Preliminary Design	43
3.4	Analisis Pembebanan Struktur Jembatan.....	47
3.5	Permodelan Struktur	47
3.6	Desain Struktur Sekunder	48
3.7	Desain Struktur Utama	48
3.8	Desain Angkur	49
3.9	Analisa Dinamis Struktur	49
3.10	Penggambaran Layout dan Detail Struktur Jembatan ..	49
BAB IV PRELIMINARY DESAIN		51
4.1	Preliminary Desain	51
4.1.1	Konfigurasi Susunan Kabel	51
4.1.2	Dimensi Gelagar Utama.....	53
4.1.3	Dimensi Gelagar	54
4.1.4	Dimensi Kabel dan Anker.....	55
4.1.5	Struktur <i>Pylon</i>	58
4.2	Perencanaan Sekunder.....	60
4.2.1	Perencanaan Pipa Sandaran	60
4.2.2	Perencanaan Tiang Sandaran	62
4.2.3	Perencanaan Pelat Lantai Kendaraan	65
BAB V STRUKTUR UTAMA.....		77
5.1	Gelagar Memanjang	77
5.1.1	Pembebanan	78
5.1.2	Perhitungan Momen	80
5.1.3	Kontrol Kekuatan Sebelum Komposit	81
5.1.4	Kontrol Lendutan	82
5.1.5	Kontrol Geser	83
5.1.6	Kontrol Kekuatan Sesudah Komposit.....	84
5.1.7	Perhitungan Shear Connector.....	87
5.1.8	Perhitungan Sambungan GelMemanjang.....	88
5.2	Gelagar Melintang	90
5.2.1	Pembebanan	90
5.2.2	Perhitungan Momen	92
5.2.3	Kontrol Kekuatan Lentur	94
5.2.4	Kontrol Lendutan	95

5.2.5	Kontrol Kekuatan Sebelum Komposit	96
5.2.6	Kontrol Kekuatan Sesudah Komposit	98
5.2.7	Perhitungan Shear Connector	101
5.2.8	Perhitungan Sambungan Gel Melintang	103
5.3	Permodelan Struktur	108
5.3.1	Analisa Statik	109
5.3.2	Analisa Dinamik	114
5.3.3	Kombinasi Beban	120
5.3.4	Pembebanan Kabel	122
5.3.5	Staging analysis	123
5.3.6	Pelaksanaan	124
5.3.7	Pembebanan	130
5.3.8	Hasil Analisa	134
5.3.9	Desain Lead Rubber Bearing	141
5.4	Gelagar Utama	143
5.4.1	Hasil Analisa Struktur	144
5.4.2	Kontrol Kemampuan Penampang	145
5.4.3	Sambungan Gelagar Utama	149
5.5	Kontrol Stabilitas Aerodinamis	154
5.5.1	Frekuensi alami	154
5.5.2	Efek vortex-shedding	157
5.5.3	Efek <i>Flutter</i> (Ayunan)	161
5.6	Data Perencanaan Kabel	166
5.6.1	Gaya Tarik (<i>Stressing</i>) Kabel	167
5.6.2	Analisa Penampang Kabel dengan A_{pakai} ...	169
5.6.3	Analisa Anker pada gelagar	170
5.7	Analisa Struktur <i>Pylon</i>	175
5.7.1	Gaya Dalam pada <i>Pylon</i>	175
5.7.2	Analisa Kelangsingan	178
5.7.3	Penulangan <i>Pylon</i>	189
2.7.4	Analisa Angkur pada <i>Pylon</i>	206
BAB VI PERENCANAAN STRUKTUR BAWAH		209
6.1	Analisa Pondasi	209

6.1.1	Perhitungan Daya Dukung Tanah	211
6.1.2	Perhitungan penulangan bored pile	214
6.1.3	Panjang penyaluran	216
6.2	Perhitungan Tulangan Pile Cap	217
BAB VII PELAKSANAAN DAN MAINTENANCE		221
7.1	Metode Pelaksanaan	221
7.2	Analisa Struktur Tahap Pelaksanaan	226
7.3	Analisa Struktur Ketika <i>Maintenance</i>	227
BAB VIII KESIMPULAN DAN SARAN		229
8.1	Kesimpulan	229
8.2	Saran	231
DAFTAR PUSTAKA		233
BIODATA PENULIS		236
LAMPIRAN		235

DAFTAR GAMBAR

Gambar 1. 1 Klasifikasi penerapan tipe jembatan berdasarkan panjang bentang (Sétra, 2003).....	2
Gambar 1. 2 Peta Lokasi Jembatan	4
Gambar 1. 3 Layout Jembatan Eksisting.....	4
Gambar 1. 4 Potongan Melintang Rencana.....	5
Gambar 1. 5 Potongan Melintang Eksisting.....	5
Gambar 1. 7 Potongan Memanjang Jembatan Rencana	6
Gambar 1. 6 Potongan Memanjang Jembatan Existing.....	6
Gambar 2. 1 Konfigurasi kabel arah memanjang (Peraturan PU No. 08/SE/M/2015) 8	
Gambar 2. 2 Jembatan dengan kabel 2 bidang (a,b) dan satu bidang (c,d) (Peraturan PU No. 08/SE/M/2015)	8
Gambar 2. 3 Wire stay cable dan strand stay cable (Peraturan PU No. 08/SE/M/2015)	9
Gambar 2. 4 Angkur mati (kiri) dan angkur hidup (kanan) (Peraturan PU No. 08/SE/M/2015)	10
Gambar 2. 5 Alternatif pengangkuran pada menara (Peraturan PU No. 08/SE/M/2016)	10
Gambar 2. 6 Lokasi angkur pada dek jembatan (Peraturan PU No. 08/SE/M/2016)	11
Gambar 2. 7 Gelagar solid web baja (Peraturan PU No. 08/SE/M2015)	12
Gambar 2. 8 Bentuk dasar menara/pylon jembatan cable-stayed (Walther 1988)	13
Gambar 2. 9 Daya Dukung Tiang Pancang	14
Gambar 2. 10 Beban Lajur “D”	15
Gambar 2. 11 Konfigurasi beban hidup (Peraturan PU No. 08/SE/M/2015)	15
Gambar 2. 12 Konfigurasi beban truk “T”	16
Gambar 2. 13 Penempatan beban truk “T”	16
Gambar 2. 14 Faktor beban dinamis untuk “T” untuk pembebanan lajur “D”	17
Gambar 2. 15 Spektrum rencana gempa (2016).....	20

Gambar 2. 16 Diagram Perhitungan Intensitas Daya Dukung Ultimate Tanah Pondasi Pada Ujung Tiang	29
Gambar 2. 17 Bentuk susunan tiang pancang.....	31
Gambar 2. 18 23 Efek angin pada penampang lantai kendaraan (Walther 1988).....	33
Gambar 2. 19 Grafik koefisien CT, CN, CM (Walther 1988)	34
Gambar 2. 20 Klasifikasi efek psikologis berdasarkan amplitudo (Walther 1988).....	36
Gambar 2. 21 Klasifikasi psikologis berdasarkan percepatan (Walther 1988).....	36
Gambar 2. 22 Representasi sederhana flutter pada dek jembatan (Walther 1988).....	37
Gambar 2. 23 Kecepatan teoritis untuk flutter (Walther 1988) ...	38
Gambar 2. 24 Contoh fenomena Flutter	38
Gambar 2. 25 Metode pelaksanaan kantilever (Parke and Huson, 2008).....	40
Gambar 2. 26 Metode pelaksanaan kantilever (Gimsing dan T.Christos , 2012)	40
Gambar 3. 1 Bagan Alir	42
Gambar 3. 2 Gelagar jenis twin box girder	43
Gambar 3. 3 Konfigurasi Kabel tipe fan patter	43
Gambar 3. 4 Posisi Kabel dengan sistem double plan.....	44
Gambar 3. 5 Gaya yang bekerja pada kabel angkur (Peraturan PU No.08/SE/M/2015)	45
Gambar 3. 6 Bentuk pylon jembatan	46
Gambar 3. 7 Permodelan 3D pada MIDAS CIVIL	47
Gambar 4. 1 <i>Long section</i> dan denah jembatan	52
Gambar 4. 2 Susunan Kabel Arah Melintang Berupa Double Planes System (dalam milimeter)	53
Gambar 4. 3 Preliminary Box Girder (dalam milimeter)	54
Gambar 4. 4 Hasil <i>preliminary</i> pylon.....	59
Gambar 4. 5 Beban yang bekerja pada pipa sandaran	60
Gambar 4. 6 Profil pipa sandaran	60
Gambar 4. 7 Detail tiang sandaran	62
Gambar 4. 8 Detail penulangan tiang sandaran.....	65

Gambar 4. 9 Lantai kendaraan	66
Gambar 4. 10 Distribusi Geser Pons	75
Gambar 5. 1 Potongan gelagar memanjang (mm)	78
Gambar 5. 2 Model perhitungan beban mati	78
Gambar 5. 3 Model perhitungan beban “D”	79
Gambar 5. 4 Model gambar perhitungan beban truk	79
Gambar 5. 5 Distribusi gaya pada penampang	84
Gambar 5. 6 Gelagar komposit	85
Gambar 5. 7 Detail sambungan gelagar memanjang (mm)	89
Gambar 5. 8 Detail sambungan memanjang ke melintang	90
Gambar 5. 9 Pembebanan akibat beban mati	91
Gambar 5. 10 Pembebanan akibat beban mati setelah komposit	91
Gambar 5. 11 Pembebanan Akibat BTR dan BGT	93
Gambar 5. 12 Pembebanan Akibat Truk (Kondisi 1)	93
Gambar 5. 13 Pembebanan Akibat Truk (Kondisi 2)	94
Gambar 5. 14 Beban geser sebelum komposit	96
Gambar 5. 15 Beban Merata Geser Setelah Komposit	97
Gambar 5. 16 Gaya Geser Akibat BTR+BGT Tak Simetris	97
Gambar 5. 17 Distribusi Gaya pada Penampang	99
Gambar 5. 18 Gelagar Komposit	100
Gambar 5. 19 Sambungan gelagar melintang ke box girder	103
Gambar 5. 20 Sambungan gelagar melintang (mm)	106
Gambar 5. 21 Detail melintang sambungan baut (mm)	107
Gambar 5. 22 Profil Shear Connector	107
Gambar 5. 23 Tampak perspektif jembatan	108
Gambar 5. 24 Tampak melintang jembatan	108
Gambar 5. 25 Tampak memanjang jembatan	109
Gambar 5. 26 Tampak atas jembatan	109
Gambar 5. 27 Tampak melintang dek jembatan	109
Gambar 5. 28 Ilustrasi beban angin kendaraan menjadi momen torsi	113
Gambar 5. 29 Data Tanah Untuk Menentukan Jenis Tanah	114
Gambar 5. 30 Grafik response spectrum	117
Gambar 5. 31 Grafik response spectrum pada MIDAS CIVIL ..	118
Gambar 5. 32 Peta respon spektra Indonesia	119

Gambar 5. 33 Gaya tarik awal tiap kabel	123
Gambar 5. 34 Segmental deck untuk staging analysis	124
Gambar 5. 35 Contoh form traveler yang digunakan	130
Gambar 5. 36 Segmen deck pada saat pengangkatan	131
Gambar 5. 37 (A) tampak depan, (B) potongan A-A	133
Gambar 5. 38 Permodelan dan input beban untuk form.....	134
Gambar 5. 39 Hasil analisa reaksi untuk form traveler	134
Gambar 5. 40 Permodelan saat Constraction Stage 0 (CS 0)	135
Gambar 5. 41 Permodelan saat Constraction Stage 1 (CS 1)	135
Gambar 5. 42 Permodelan saat Constraction Stage 1 (CS 1)	135
Gambar 5. 43 Permodelan saat Constraction Stage 3 (CS 3)	136
Gambar 5. 44 Permodelan saat Constraction Stage 4 (CS 4)	136
Gambar 5. 45 PermodelansaatConstraction Stage 5 (CS 5)	136
Gambar 5. 46 Permodelan saat Constraction Stage 6 (CS 6)	137
Gambar 5. 47 Permodelan saat Constraction Stage 7 (CS 7)	137
Gambar 5. 48 Permodelan saat Constraction Stage8 (CS 8)	137
Gambar 5. 49 Permodelan saat Constraction Stage 9 (CS 9)	138
Gambar 5. 50 Permodelan saat Constraction Stage 10 (CS 10)	138
Gambar 5. 51 PermodelansaatConstraction Stage 11 (CS 11) ..	138
Gambar 5. 52 Permodelan saat Constraction Stage 12 (CS 12)	139
Gambar 5. 53 Permodelan saat Constraction Stage 13 (CS 13)	139
Gambar 5. 54 Permodelan saat Constraction Stage 14 (CS 14)	139
Gambar 5. 55 Permodelan saat Constraction Stage 15 (CS 15)	140
Gambar 5. 56 Permodelan saat Constraction Stage 16 (CS 16)	140
Gambar 5. 57 Permodelan saat Constraction Stage 17 (CS 17)	140
Gambar 5. 58 Lead rubber bearing (LRB)	141
Gambar 5. 59 Dimensi gelagar utama (dalam mm).....	143
Gambar 5. 60 Analisa section data dan section properties	144
Gambar 5. 61 Sambungan pada sayap atau sisi atas dan bawah.....	153
Gambar 5. 62 Sambungan pada badan atau sisi samping.....	153
Gambar 5. 63 Sambungan pada potongan melintang gelagar utama	154
Gambar 5. 64 Mode 1 - 12 frekuensi lentur (fB) dan frekuensi torsi (fT).....	156
Gambar 5. 65 Koefisien CN	159

Gambar 5. 66 Macam-macam penampang deck	159
Gambar 5. 67 Klasifikasi efek psikologis berdasarkan amplitudo (Walther, 1999)	160
Gambar 5. 68 Klasifikasi efek psikologis berdasarkan percepatan getaran (Walther, 1999).....	161
Gambar 5. 69 Efek ayunan dengan beda fase $\pi/2$	162
Gambar 5. 70 Kecepatan kritis teoritis untuk flutter	164
Gambar 5. 71 Grafik koefisien koreksi (Walther, 1999).....	165
Gambar 5. 72 Penamaan dan penomoran kabel	166
Gambar 5. 73 Spesifikasi teknis dan karakteristik anker	171
Gambar 5. 74 Pelat anker dan dimensi	173
Gambar 5. 75 Potongan memanjang struktur pylon	175
Gambar 5. 76 Penampang pylon	179
Gambar 5. 77 Pemodelan penulangan section-A-A	190
Gambar 5. 78 Diagram interaksi Mx-My analisa spColumn	191
Gambar 5. 79 Diagram interaksi P-M analisa spColumn	191
Gambar 5. 80 Pemodelan penulangan section-2	192
Gambar 5. 81 Diagram interaksi Mx-My analisa spColumn	192
Gambar 5. 82 Diagram interaksi P-M analisa spColumn	193
Gambar 5. 83 Pemodelan penulangan section-2	193
Gambar 5. 84 Diagram interaksi Mx-My analisa spColumn	194
Gambar 5. 85 Diagram interaksi P-M analisa spColumn	194
Gambar 5. 86 Pemodelan penulangan section-2	195
Gambar 5. 87 Diagram interaksi Mx-My analisa spColumn	196
Gambar 5. 88 Diagram interaksi P-M analisa spColumn	196
Gambar 5. 89 Detail ajustable anchorage VSL SSI 2000.....	207
Gambar 6. 1 Denah pondasi	209
Gambar 6. 4 grafik hasil input SpCacol,	215
Gambar 7. 1 Tahap pertama pelaksanaan	221
Gambar 7. 2 Tahap kedua pelaksanaan	222
Gambar 7. 3 Tahap ketiga pelaksanaan.....	222
Gambar 7. 4 Tahap keempat pelaksanaan	223
Gambar 7. 5 Tahap kelima pelaksanaan.....	223
Gambar 7. 6 Tahap keenam pelaksanaan	224
Gambar 7. 7 Tahap ketujuh pelaksanaan.....	224

Gambar 7. 8 Tahap kedelapan pelaksanaan.....225

Gambar 7. 9 Tahap kesembilan pelaksanaan.....225

Gambar 7. 10 Tahap kesepuluh pelaksanaan.....226

Gambar 7. 11 Tahap kesebelas pelaksanaan.....226

Gambar 7. 12 kabel dilepas pada tahap maintenance228

DAFTAR TABEL

Tabel 2. 1 spesifikasi kelas situs tanah.....	18
Tabel 2. 2 faktor amplifikasi periode 0detik dan 0,2detik.....	19
Tabel 2. 3 nilai faktor amplifikasi untuk periode 1 detik (F_v)	19
Tabel 2. 4 Kombinasi pembebanan (Tabel 1 SNI 1725 2016)	21
Tabel 2. 5 Faktor panjang efektif	24
Tabel 2. 6 Faktor Keamanan	30
Tabel 4. 1 Mutu kabel	55
Tabel 4. 2 Perhitungan jumlah strand dalam setiap susunan kabel	58
Tabel 4. 3 Rekapitulasi gaya yang bekerja pada pylon	59
Tabel 4. 4 Nilai V_0 dan Z_0	67
Tabel 4. 5 Tekanan angin dasar.....	67
Tabel 4. 6 Rekapitulasi momen lapangan dan tumpuan.....	70
Tabel 4. 7 Kombinasi 1 Momen Lapangan Pada Pelat	70
Tabel 4. 8 Tabel 5. 5 Kombinasi 2 Momen Lapangan Pada Pelat	70
Tabel 4. 9 Kombinasi 1 Momen Tumpuan Pada Pelat	71
Tabel 4. 10 Kombinasi 2 Momen Tumpuan Pada Pelat	71
Tabel 5. 1 Rekapitulasi beban	80
Tabel 5. 2 Garis Netral Penampang Komposit.....	86
Tabel 5. 3 Momen Inersia Penampang	87
Tabel 5. 4 Rekapitulasi beban	92
Tabel 5. 5 Garis Netral Penampang Komposit.....	101
Tabel 5. 6 Momen Inersia Penampang	101
Tabel 5. 7 Nilai V_0 dan Z_0 untuk variasi kondisi permukaan	111
Tabel 5. 8 Tekanan angin dasar.....	112
Tabel 5. 9 Sifat bahan rata-rata akibat pengaruh temperatur.....	113
Tabel 5. 10 Temperatur jembatan rata-rata nominal	113
Tabel 5. 11 Koefisien Situs, F_a dan Koefisien Situs, F_v	115
Tabel 5. 12 Tabel Zona Gempa	115
Tabel 5. 13 Perhitungan Respon Spektrum	116
Tabel 5. 14 Faktor modifikasi	118
Tabel 5. 15 Kombinasi pembebanan untuk analisa statik	120
Tabel 5. 16 Ilustrasi dari konfigurasi beban tampak atas	120

Tabel 5. 17 Kombinasi pembebanan untuk analisa dinamik	122
Tabel 5. 18 Ilustrasi dari konfigurasi beban tampak atas	122
Tabel 5. 19 FT-S form traveler overhead model specification ..	131
Tabel 5. 20 Konfigurasi pembebanan saat staging analysis	132
Tabel 5. 21 Dimensi Mageba LASTO LRB	142
Tabel 5. 22 Gaya maksimum pada LRB.....	142
Tabel 5. 23 Gaya dalam pada gelagar utama	145
Tabel 5. 24 Nilai fB dan fT.....	157
Tabel 5. 25 Jumlah strand dan luas kabel pada preliminary	167
Tabel 5. 26 Gaya tarik awal (stressing) pada kabel	167
Tabel 5. 27 Kebutuhan luas akibat pretension.....	168
Tabel 5. 28 Gaya tarik masing-masing kabel	168
Tabel 5. 29 Kebutuhan strand dan luas penampang sebenarnya	169
Tabel 5. 30 Hasil analisa gaya tarik dari Apakai	169
Tabel 5. 31 Kemampuan kabel dari Aspakai.....	170
Tabel 5. 32 Data anker yang dipakai	172
Tabel 5. 33 Perhitungan anker keseluruhan.....	173
Tabel 5. 34 Gaya dalam maksimum-X1 untuk pylon.....	176
Tabel 5. 35 Gaya dalam maksimum-Y1 untuk pylon.....	176
Tabel 5. 36 Gaya dalam maksimum-X2 untuk pylon.....	176
Tabel 5. 37 Gaya dalam maksimum-Y2 untuk pylon.....	177
Tabel 5. 38 Gaya dalam maksimum-X2 untuk pylon.....	177
Tabel 5. 39 Gaya dalam maksimum-Y2 untuk pylon.....	177
Tabel 5. 40 Gaya dalam maksimum-X2 untuk pylon.....	177
Tabel 5. 41 Gaya dalam maksimum-Y2 untuk pylon.....	178
Tabel 5. 42 Rekapitulasi gaya pada pylon	189
Tabel 5. 43 Gaya dalam pada kabel.....	206
Tabel 6. 1 Perhitungan spring	210
Tabel 6. 2 Hasil permodelan.....	211
Tabel 6. 3 Perhitungan daya dukung ijin tanah	212
Tabel 6. 4 Reaksi yang terjadi pada borepile.....	214
Tabel 7. 1 Kapasitas box girder	227
Tabel 7. 2 Kapasitas box girder.....	228

BAB I

PENDAHULUAN

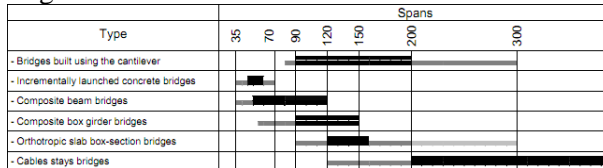
1.1 Latar Belakang

Transportasi merupakan salah satu kebutuhan yang penting dalam menggerakkan roda perekonomian masyarakat, selain untuk mempersingkat waktu tempuh dan memindahkan suatu objek, transportasi juga berfungsi untuk melancarkan hubungan antara satu lokasi dengan lokasi yang lain dan kebutuhan akan sarana dan prasarana transportasi di Indonesia dilihat dari tahun ke tahun mengalami fase perkembangan dan peningkatan. Untuk mendukung peningkatan kebutuhan sarana dan prasarana dalam akses transportasi tersebut, maka pemerintah membuat program pembangunan *Trans Java Tollway System* yang salah satunya adalah pembangunan Proyek Tol Pasuruan-Probolinggo, di mana terdapat jembatan pada Sta. 29+325.

Jembatan Tol Pasuruan-Probolinggo Sta. 29+325 terletak Kecamatan Leces Kabupaten Probolinggo Jawa Timur. Jembatan ini merupakan jembatan yang melewati Jalan Raya Leces yang merupakan jalan provinsi dan Jalan Rel. Jembatan ini memiliki panjang bentang total 144 m dan lebar jembatan 17,5 m dengan dua lajur dua arah. Struktur pada bangunan atas jembatan ini menggunakan beton pratekan (*Prestressed Concrete*) dengan bentuk girder I. Jembatan ini diharapkan menjadi jalur kendaraan-kendaraan berat yang akan mendistribusikan hasil perindustrian di Pulau Jawa.

Pada Tugas Akhir ini Jembatan tersebut direncanakan ulang menggunakan Jembatan *Cable-Stayed* dengan bentang 144 m. Dengan menggunakan sistem *cable-stayed* juga maka jembatan dapat didesain dengan bentang yang lebih panjang sehingga akan mengurangi jumlah pilar yang digunakan. Untuk jembatan *cable-stayed* penggunaan bentang minimum

adalah 120 meter. Hal ini dijelaskan dalam “Prestressed Concrete Bridges Built Using the Cantilever Method” oleh Departemen Teknis untuk Transportasi, Jalan dan Rekayasa Jembatan, dan Keselamatan Jalan (S  tra) Republik Perancis pada gambar 1.1



Gambar 1. 1 Klasifikasi penerapan tipe jembatan berdasarkan panjang bentang (S  tra, 2003)

Selain mengurangi jumlah penggunaan pilar, jembatan *cable-stayed* juga mengurangi tinggi dek jembatan. Dalam Pasal 4.6.2 Peraturan PU Nomor 08/SE/M/2015 dijelaskan kisaran tinggi *girder* untuk jembatan *cable-stayed* adalah 1/50 sampai dengan 1/70 dari panjang bentang utama. Dari segi estetika, jembatan *cable-stayed* memiliki estetika yang sangat indah jika dibandingkan tipe jembatan lain. Sehingga selain untuk prasarana transportasi, jembatan tersebut juga dapat dijadikan *landmark* kota tersebut.

1.2 Rumusan Masalah

Berdasarkan uraian latar belakang di atas, maka diperlukan perincian permasalahan secara detail untuk melakukan modifikasi jembatan Tol Pasuruan-Probolinggo Sta.29+325 menggunakan sistem *cable-stayed*. Rumusan masalah tersebut:

1. Bagaimana merencanakan struktur jembatan Tol Pasuruan-Probolinggo Sta. 29+325 dengan struktur *cable-stayed*?
2. Bagaimana perawatan struktur jembatan *cable-stayed* Tol Pasuruan-Probolinggo Sta. 29+325?
3. Bagaimanan menyajikan hasil desain dan analisa ke dalam gambar teknik?

1.3 Maksud dan Tujuan

Tujuan penulis melakukan tugas akhir ini secara umum adalah untuk memenuhi persyaratan kelulusan akademik dan untuk mengaplikasikan disiplin ilmu yang telah dipelajari

selama perkuliahan. Sedangkan secara khusus ialah untuk melakukan desain ulang jembatan Tol Pasuruan-Probolinggo Sta. 29+325 menggunakan sistem *cable-stayed*.

Adapun tujuan dari penyusunan tugas akhir ini berdasarkan rumusan masalah diatas meliputi:

1. Mampu merencanakan struktur jembatan Tol Pasuruan-Probolinggo Sta. 29+325 dengan struktur *cable-stayed*
2. Mampu merencanakan perawatan struktur jembatan *cable-stayed* Tol Pasuruan-Probolinggo Sta. 29+325?
3. Mampu menyajikan hasil desain dan analisa ke dalam gambar teknik

1.4 Manfaat

Penyusunan tugas akhir ini diharapkan memberikan manfaat sebagai berikut:

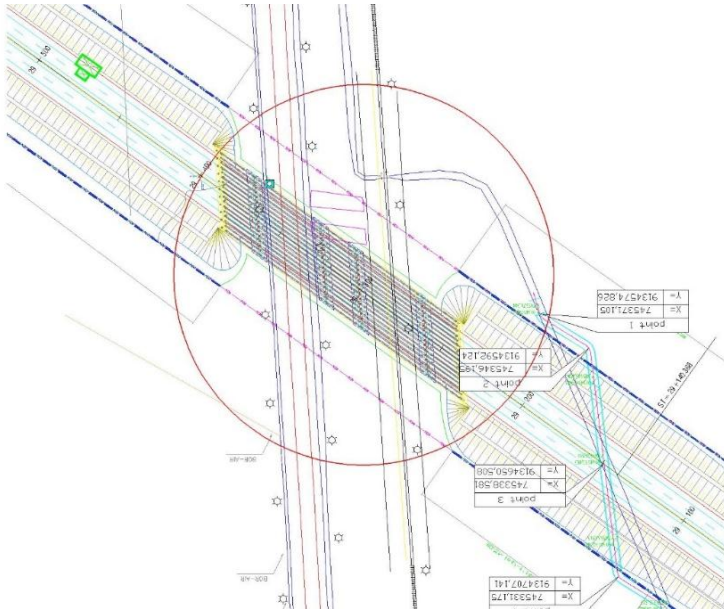
1. Dapat memahami konsep dan merencanakan desain struktur jembatan dengan profil box baja yang sesuai dengan persyaratan struktur yang ditentukan
2. Sebagai alternatif lain dalam teknik desain jembatan dengan bentang panjang

1.5 Batasan Masalah

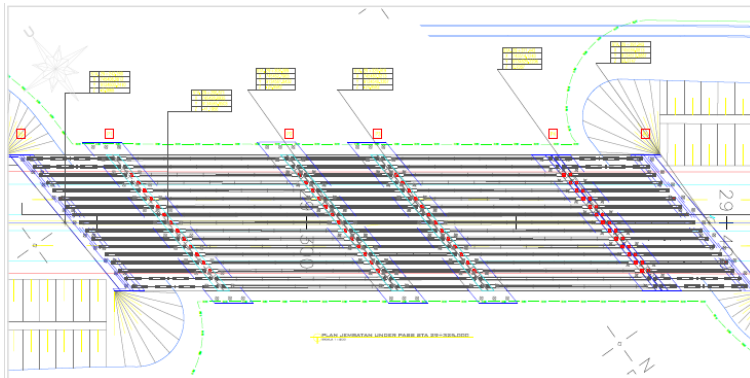
Dikerdanakan keterbatasan waktu dalam penyusunan tugas akhir ini, maka penulis membatasi permasalahan yang ada. Batasan masalah tersebut diantaranya:

1. Tidak melakukan analisa dampak lingkungan dalam menentukan tipe jembatan
2. Tidak melakukan analisa anggaran biaya dan waktu pelaksanaan
3. Teknik pelaksanaan dibahas secara umum
4. Tidak melakukan perhitungan *abutment* jembatan

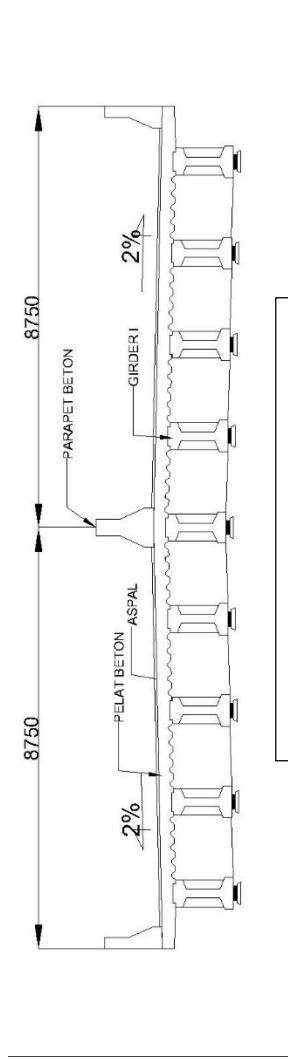
1.6 Peta Lokasi



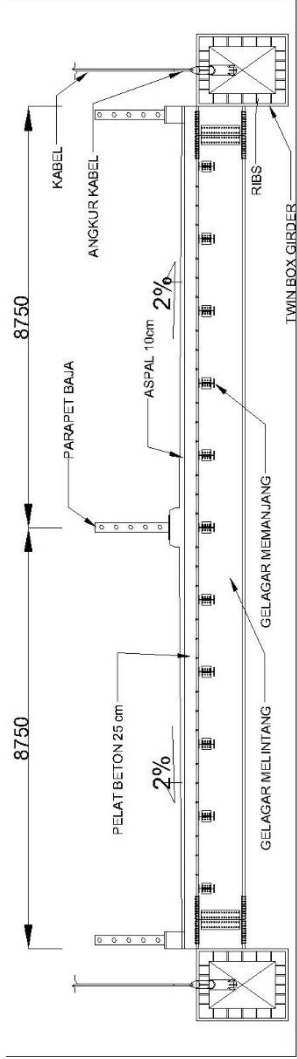
Gambar 1. 2 Peta Lokasi Jembatan



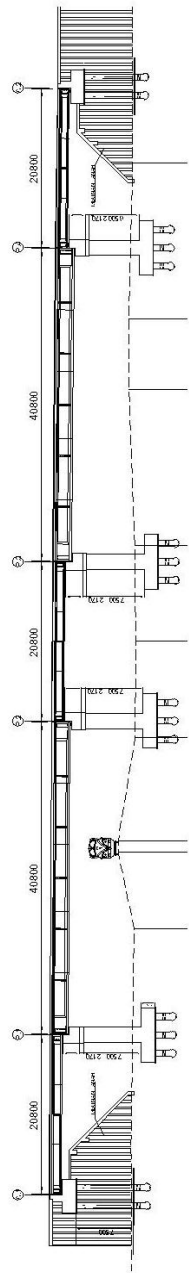
Gambar 1. 3 Layout Jembatan Eksisting



Gambar 1. 5 Potongan Melintang Eksisting

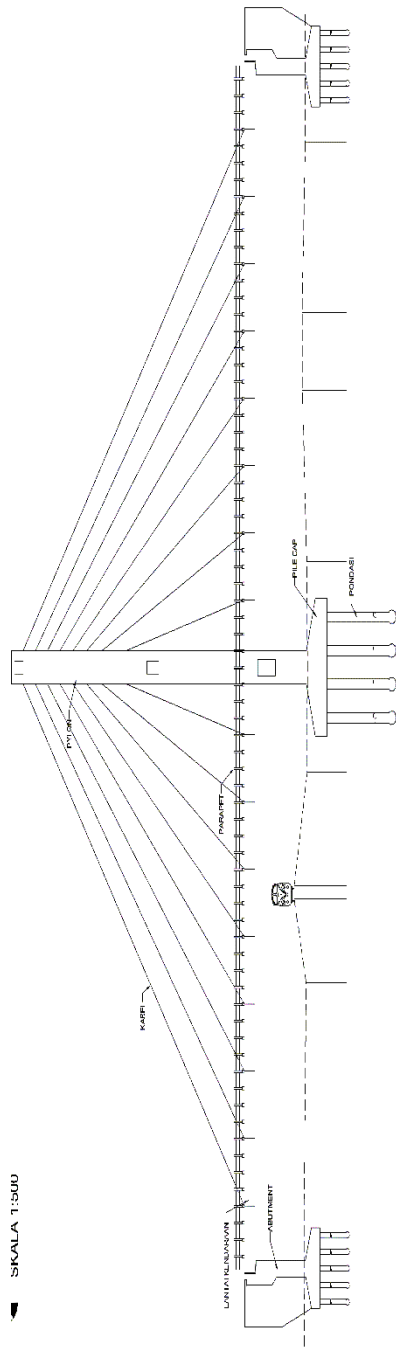


Gambar 1. 4 Potongan Melintang Rencana



Gambar 1. 7 Potongan Memanjang Jembatan Existing

SKALA 1:500



Gambar 1. 6 Potongan Memanjang Jembatan Rencana

BAB II

TINJAUAN PUSTAKA

2.1 Umum

Jembatan *cable-stayed* (beruji kabel) adalah struktur yang mempunyai sederetan kabel lurus dan memikul elemen horizontal kaku (berupa balok, rangka, atau *box*). Jembatan *cable-stayed* terdiri dari sistem struktur berupa gelagar menerus yang didukung oleh tumpuan berupa kabel yang dibentangkan miring dan dihubungkan ke menara sebagai penahan utama. (Kementerian Pekerjaan Umum, 2015).

2.2 Komponen Struktur Jembatan Cable Stayed

Sistem *cable-stayed* pada jembatan dapat diartikan sebagai sebuah sistem struktur yang terdiri dari dek dan *girder* menerus yang diikat oleh *incline cable* dan didistribusikan ke menara yang terletak pada pilar utama (Troitsky 1977). Jembatan *cable-stayed* terdiri dari elemen-elemen utama yang berupa gelagar atau *girder*, kabel, dan menara yang disebut *pylon* pada *upperstructure* serta abutmen dan pondasi sebagai komponen bangunan bawah jembatan.

2.2.1 Bangunan Atas

2.2.1.1 Komponen Kabel

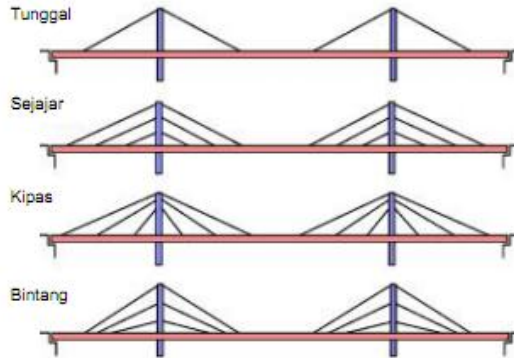
a. Konfigurasi Kabel

Penentuan konfigurasi dan jumlah kabel-kabel tersebut didasarkan atas berbagai hal, diantaranya adalah panjang bentang, jenis beban, jumlah lajur atau lebar jembatan, tinggi menara, dan estetika. (Troitsky 1977).

i. Konfigurasi Kabel dalam Arah Memanjang

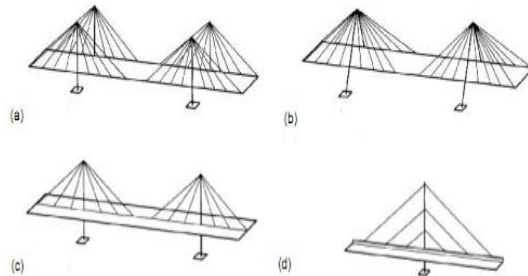
Dalam Pasal 4.4.2 Peraturan PU Nomor 08/SE/M/2015, dijelaskan tentang macam-macam konfigurasi kabel dalam arah memanjang, diantaranya adalah:

1. Pola Tunggal (*Mono Pattern*)
2. Pola Sejajar (*Harp Pattern*)
3. Pola Kipas (*Fan Pattern*)
4. Pola Bintang (*Star Pattern*)



Gambar 2. 1 Konfigurasi kabel arah memanjang (Peraturan PU No. 08/SE/M/2015)

- ii. Konfigurasi Kabel dalam Arah Melintang
 1. Sistem Satu Bidang (*Single Plane System*)
 2. Sistem dua bidang (*Double Plane System*)
 3. Sistem Tiga Bidang atau Lebih



Gambar 2. 2 Jembatan dengan kabel 2 bidang (a,b) dan satu bidang (c,d) (Peraturan PU No. 08/SE/M/2015)

- b. Jenis Kabel

Jenis-jenis kabel yang digunakan sebagai penyangga utama jembatan *cable-stayed* ada bermacam-macam.

Dalam Pasal 4.8.1 Peraturan PU Nomor 08/SE/M/2015, jenis-jenis kabel diklasifikasikan pada tabel di bawah.

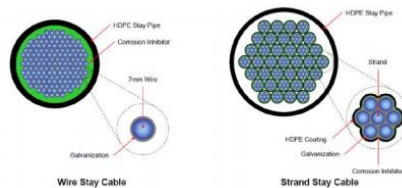
Kabel yang sering digunakan dalam desain jembatan cable-stayed adalah sebagai berikut:

i. *Parallel Wire Cable*

Parallel wire cable terdiri dari kawat bulat digalvanis berdiameter 5 mm sampai 7 mm berbentuk hexagonal, dengan suatu helix panjang. Kawat tersebut biasanya dibungkus oleh *High Density Polythelene (HDPE) tube*.

ii. *Parallel Strand Cable*

Parallel stand cable terdiri dari beberapa strand. Strand-strand tersebut selanjutnya dipasang secara paralel. Setiap kabel terdiri dari beberapa strand antara lain sebesar 7, 19, 37, 61, 91, atau 127 buah.



Gambar 2. 3 Wire stay cable dan strand stay cable (Peraturan PU No. 08/SE/M/2015)

2.2.1.2 Angkur Kabel

a. Sistem Pengangkuran

Secara struktural angkur pada jembatan *cable-stayed* berfungsi sebagaiudukan vertikal bagi gelagar, sehingga hampir semua beban vertikal bekerja pada angkur. Hal ini berbeda dengan sistem pratekan yang umumnya terletak di luar daerah kritis dan dengan variasi tegangan yang sangat kecil. Karena dari itu tegangan yang diijinkan untuk angkur jembatan *cable-stayed* relatif kecil.

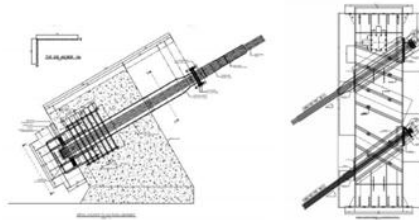
Secara umum terdapat dua sistem pengangkuran pada jembata *cable-stayed*, yaitu:

i. Angkur Hidup

Pengankuran dilakukan pada ujung kabel, dimana pada bagian ini dilakukan pemberian tegangan. Angkur hidup biasanya diletakkan di menara jembatan.

ii. Angkur Mati

Pengankuran dilakukan pada ujung kabel, tetapi pada bagian ini tidak dilakukan pemberian tegangan. Angkur mati biasanya diletakkan di dek jembatan.

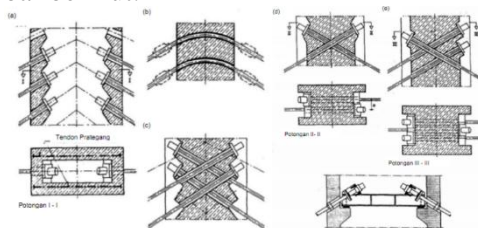


Gambar 2. 4 Angkur mati (kiri) dan angkur hidup (kanan)
(Peraturan PU No. 08/SE/M/2015)

b. Posisi dan Detail Pengankuran

i. Pengankuran pada Menara

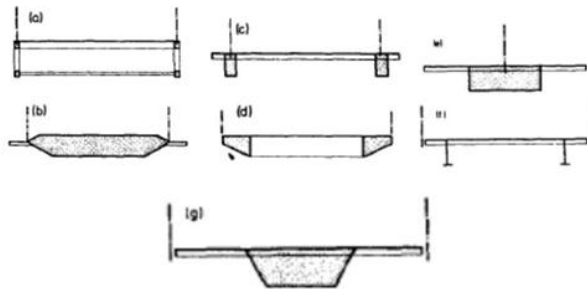
Bagian dari kabel yang masuk ke dalam menara ditempatkan di dalam suatu pipa pengarah/*guide pipe* dari konstruksi baja menembus dari sisi main span ke sisi side span dan sebaliknya. Ada beberapa alternatif pengankuran pada menara sebagaimana disajikan pada gambar berikut:



Gambar 2. 5 Alternatif pengankuran pada menara (Peraturan PU No. 08/SE/M/2016)

ii. Pengangkur pada Dek Jembatan

Aliran dari gaya-gaya sangat penting untuk diperhatikan ketika mendesain jembatan *cable-stayed*. Pada kasus tertentu, kabel dapat langsung diangkurkan ke elemen utama dek jembatan, sedangkan pada kasus lain angkur harus diletakkan di luar elemen utama sehingga diperlukan *bracker* khusus untuk menyalurkan gaya ke elemen utama dek jembatan. Berikut lokasi pengangkur pada dek jembatan:



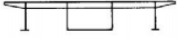
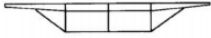





Gambar 2. 6 Lokasi angkur pada dek jembatan (Peraturan PU No. 08/SE/M/2016)

2.2.1.3 Lantai Kendaraan Jembatan (*Bridge Deck*)

Terdapat banyak variasi tipe gelagar untuk jembatan *cable-stayed*, namun hanya tiga tipe umumnya digunakan yaitu rangka pengaku baja, *solid web* beton, dan *solid web* baja. Pada perkembangan awal rangka pengaku baja banyak digunakan, namun kini sudah jarang digunakan karena pabrikan yang membutuhkan biaya relatif besar, perawatan yang sulit dan kurang menarik dari segi estetika.

Dalam desain jembatan *cable-stayed* untuk tugas akhir ini digunakan *twin steel box girder*. Berikut klasifikasinya menurut Peraturan PU Nomor 08/SE/M/2015:

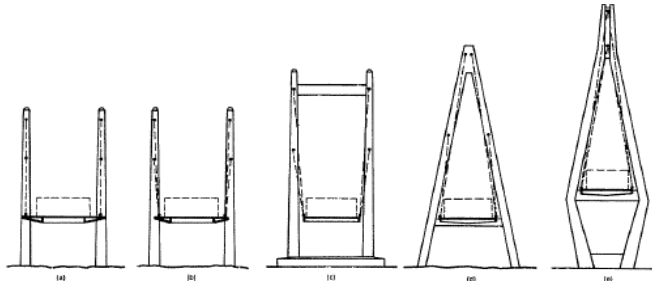
No	Komposisi	Penampang Jembatan
1	<i>Twin I Girder</i>	
2	<i>Single Rectangular Box Girder</i>	
3	<i>Central Box Girder dan Single Single Web Girder</i>	
4	<i>Single Twin Cellular Box Girder dan Sloping Struts</i>	
5	<i>Single Trapezoidal Box Girder</i>	
6	<i>Twin Rectangular Box Girder</i>	
7	<i>Twin Trapezoidal Box Girder</i>	

Gambar 2. 7 Gelagar solid web baja (Peraturan PU No. 08/SE/M2015)

2.2.1.4 Menara/Pylon

Perencanaan menara merupakan hal yang sangat penting dan mendasar yang akan mempengaruhi estetika, keekonomisan serta perilaku struktur dari jembatan.

Bentuk dasar menara jembatan *cable-stayed* ada beberapa macam, seperti ditampilkan pada gambar di bawah. Pemilihan bentuk menara ditentukan oleh konfigurasi kabel, bentang jembatan dan aspek estetika.



Gambar 2. 8 Bentuk dasar menara/pylon jembatan cable-stayed
(Walther 1988)

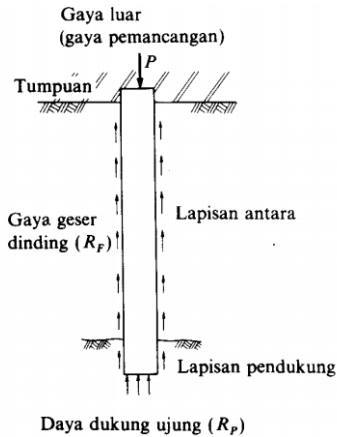
2.2.2 Bangunan Bawah

2.2.2.1 Pilar

Pilar jembatan memiliki dua fungsi utama yaitu; mentransfer beban bangunan atas vertikal ke pondasi dan menahan kekuatan horisontal yang bekerja pada jembatan. Meskipun pilar secara umum dirancang untuk menahan beban vertikal dari struktur di atasnya, pilar juga didesain untuk menahan beban lateral tinggi disebabkan oleh peristiwa seismik.

2.2.2.2 Pondasi

Perencanaan pondasi yang akan digunakan harus memperhitungkan jenis tanah di lokasi tersebut. Untuk mengetahui jenis tanah maka harus memiliki data tanah yang berupa data SPT maupun data property tanah itu, untuk mengetahui letak tanah keras pada kedalaman berapa meter. Setelah mengetahui letak tanah keras maka bisa dipilih jenis pondasi yang akan digunakan, untuk letak tanah keras yang lebih dari 10 meter bisa menggunakan jenis pondasi dalam sehingga beban yang terjadi dapat disalurkan ke tanah keras.



Gambar 2. 9 Daya Dukung Tiang Pancang

2.3 Pembebanan Jembatan

Peraturan pembebanan yang digunakan dalam desain jembatan *cabl-stayed* ini adalah peraturan SNI 1725-2016. Beban-beban yang akan direncanakan meliputi:

2.3.1 Beban Permanen

a. Beban Mati

Beban mati dalam struktur jembatan merupakan berat bagian dari elemen-elemen struktural dan juga elemen-elemen lain yang dipikul oleh jembatan. Berat dari bagian-bagian tersebut adalah massa dikalikan percepatan gravitasi (g). Di mana percepatan gravitasi yang digunakan adalah sebesar $9,81 \text{ m/detik}^2$.

b. Beban Mati Tambahan

Beban mati tambahan adalah berat seluruh bahan yang membentuk suatu beban pada jembatan yang merupakan elemen nonstruktural, dan besarnya dapat berubah selama umur rencana jembatan. Faktor beban mati tambahan diberikan pada tabel berikut.

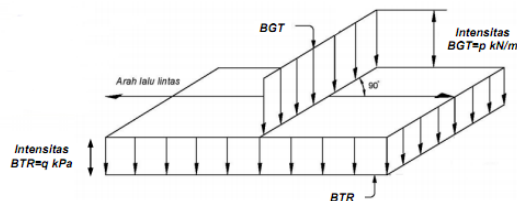
2.3.2 Beban Lalu Lintas

a. Beban Lajur “D”

Beban lajur “D” terdiri atas beban terbagi rata (BTR) yang digabungkan dengan beban garis (BGT) seperti terlihat pada gambar. Beban terbagi rata (BTR) mempunyai intensitas q kPa dengan besaran q tergantung pada panjang total yang dibebani L yaitu sebagai berikut:

Jika $L \leq 30$ m : $q = 9,0$ kPa

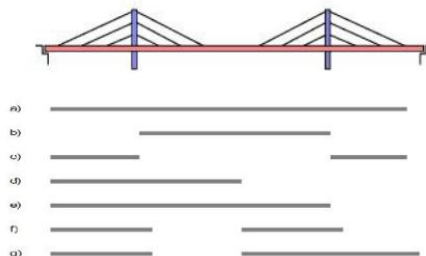
Jika $L > 30$ m : $q = 9,0 \left(0,5 + \frac{15}{L} \right)$ kPa



Gambar 2. 10 Beban Lajur “D”

Sedangkan untuk beban garis (BGT) besarnya adalah 49,0 kN/m dan ditempatkan tegak lurus terhadap arah lalu lintas pada jembatan, seperti terlihat pada gambar di atas.

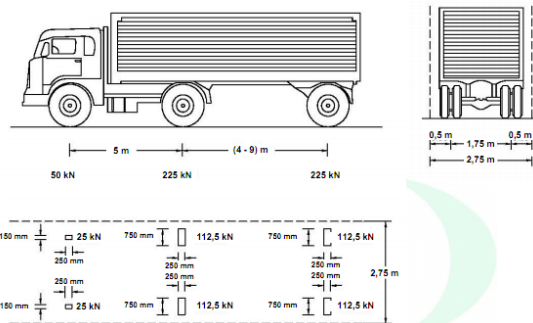
Beban “D” disusun pada arah melintang horizontal sedemikian rupa sehingga menimbulkan momen maksimum. Untuk jembatan *cable-stayed* distribusi beban “D” dijelaskan dalam Pasal 10.1 Peraturan PU Nomor 08/SE/M/2015 sebagai berikut:



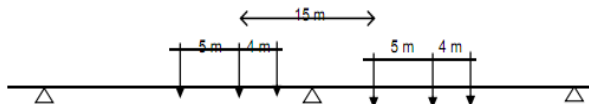
Gambar 2. 11 Konfigurasi beban hidup (Peraturan PU No. 08/SE/M/2015)

b. Beban Truk

Beban truk “T” tidak dapat digunakan bersamaan dengan beban “D”. Beban truk dapat digunakan untuk perhitungan struktur lantai. Untuk besarnya pembebanan truk “T”, diklasifikasikan pada gambar berikut:



Gambar 2. 12 Konfigurasi beban truk “T”

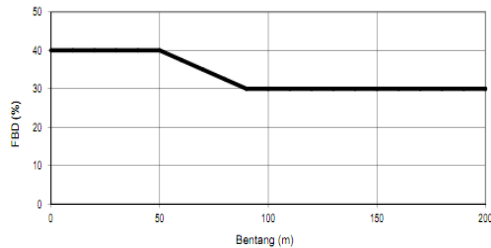


Gambar 2. 13 Penempatan beban truk “T”

c. Faktor Beban Dinamis

Faktor beban dinamis (FBD) diterapkan untuk beban truk rencana, sedangkan untuk gaya sentrifugal, gaya rem, tidak perlu diperbesar dengan faktor beban dinamis. Faktor beban dinamis juga tidak perlu diterapkan pada beban pejalan kaki atau beban terbagi rata (BTR).

Untuk pembebanan truk “T”, FBD diambil 30%. Nilai FBD yang dihitung digunakan pada seluruh bagian bangunan yang berada di atas permukaan tanah. Untuk bagian bangunan bawah dan fondasi yang berada di bawah garis permukaan, nilai FBD harus diambil sebagai peralihan linier dari nilai ada garis permukaan tanah sampai nol pada kedalaman 2 m.



Gambar 2. 14 Faktor beban dinamis untuk “T” untuk pembebanan lajur “D”

2.3.3 Aksi Lingkungan

a. Beban Angin

1. Tekanan angin horizontal.

Tekanan angin yang ditentukan untuk angin horizontal diasumsikan disebabkan oleh angin rencana dengan kecepatan dasar (V_B) sebesar 90 hingga 126 km/jam. Gaya total beban angin tidak boleh diambil kurang dari 4,4 kN/mm pada bidang tekan dan 2,2 kN/mm pada bidang hisap pada struktur rangka dan pelengkung, serta tidak kurang dari 4,4 kN/mm.

2. Tekanan angin vertikal.

Pasal 9.6.2 SNI 1725 2016 menyatakan bahwa jembatan harus mampu memikul beban garis memanjang jembatan yang merepresentasikan gaya angin vertikal ke atas sebesar $9,6 \times 10^{-4}$ MPa dikalikan lebar jembatan, termasuk parapet dan trotoar.

b. Pengaruh Gempa

Analisa beban gempa untuk jembatan mengacu pada SNI 2833 2016 tentang “Perancangan Jembatan Terhadap Gempa”. Pemilihan metode analisis gempa dijelaskan dalam Pasal 6.3.1 SNI 2833 2016 sebagai berikut.

i. Penentuan kelas situs tanah :

$$\bar{N} = \frac{\sum_{i=1}^m t_i}{\sum_{i=1}^m \left(\frac{t_i}{\bar{N}} \right)} \quad \bar{V}_s = \frac{\sum_{i=1}^m t_i}{\sum_{i=1}^m \left(\frac{t_i}{v_{si}} \right)} \quad \bar{S}_u = \frac{\sum_{i=1}^m t_i}{\sum_{i=1}^m \left(\frac{t_i}{s_{ui}} \right)}$$

- V_s = nilai rata-rata cepat rambat gelombang geser
 N = hasil uji penetrasi standar
 S_u = kuat geser tak terdrainase dengan tebal lapisan tanah sebagai besaran pembobotnya
 t_i = tebal lapisan tanah ke- i
 V_{si} = kecepatan rambat gelombang geser melalui lapisan tanah ke- i
 N_i = nilai hasil uji penetrasi standar lapis tanah ke- i
 S_{ui} = kuat geser tak terdrainase lapis tanah ke- i
 m = jumlah lapis tanah yang ada di atas batuan dasar.
 Dari hasil yang didapat pada perhitungan diatas dapat ditentukan kelas situs menggunakan tabel berikut.

Tabel 2. 1 spesifikasi kelas situs tanah

Kelas Situs	\tilde{v} (m/s)	\dot{N}	S_u (kPa)
A. Batuan Keras	$\tilde{v} \geq 1500$	\dot{N} / A	N/A
B. Batuan	$\tilde{v} \leq 1500$	\dot{N} / A	N/A
C. Tanah Sangat Padat dan Batuan Lunak	$350 < \tilde{v} \leq 750$	$\dot{N} > 50$	$S_u \geq 100$
D. Tanah sedang	$175 < \tilde{v} \leq 350$	$15 \leq \dot{N} \leq 50$	$50 \leq S_u \leq 100$
E. Tanah Lunak	$\tilde{v} < 175$	$\dot{N} \leq 15$	$S_u \leq 50$
	Atau setiap profil lapisan tanah dengan ketebalan lebih dari 3 m dengan karakteristik sebagai berikut: a. Indeks plastisitas $PI > 2$ b. Kadar air $(w) \geq 40\%$ c. Kuat geser tak terdrainase $S_u < 25$ kPa		
F. Lokasi yang membutuhkan penyelidikan geoteknik dan analisis respons	Setiap profil lapisan tanah yang memiliki salah satu atau lebih dari karakteristik seperti : a. Rentan dan berpotensi gagal terhadap beban gempa seperti likuifaksi, tanah lempung sangat sensitif, tanah tersementasi lemah		

dinamik spesifik	b. Lempung organik tinggi dan/atau gambut (dengan ketebalan $> 3\text{m}$) c. Plastisitas tinggi (ketebalan $H > 7.5\text{m}$ dengan $PI > 75$) d. Lapisan lempung lunak/medium kaku dengan ketebalan $H > 35\text{m}$
------------------	--

ii. Penentuan faktor situs

Untuk penentuan respon spektrum di permukaan tanah diperlukan suatu faktor amplifikasi pada period nol detik (F_{PGA}) periode pendek $T=0,2$ detik (F_A) dan periode 1 detik (F_v)

Tabel 2. 2 faktor amplifikasi periode 0detik dan 0,2detik

Kelas situs	$PGA \leq 0,1$ $S_s \leq 0,25$	$PGA=0,2$ $S_s=0,5$	$PGA=0,3$ $S_s=0,75$	$PGA=0,4$ $S_s=1$	$PGA > 0,5$ $S_s \geq 1,25$
Batuan Keras (SA)	0,8	0,8	0,8	0,8	0,8
Batuan (SB)	1	1	1	1	1
Tanah Keras (SC)	1,2	1,2	1,1	1,0	1,0
Tanah Sedang (SD)	1,6	1,4	1,2	1,1	1,0
Tanah Lunak (SE)	2,5	1,7	1,2	0,9	0,9
Tanah Khusus (SF)	SS	SS	SS	SS	SS

Tabel 2. 3 nilai faktor amplifikasi untuk periode 1 detik (F_v)

Kelas situs	$S_1 \leq 0,1$	$S_1 \leq 0,2$	$S_1 \leq 0,3$	$S_1 \leq 0,4$	$S_1 \leq 0,5$
Batuan Keras (SA)	0,8	0,8	0,8	0,8	0,8
Batuan (SB)	1	1	1	1	1

Tanah Keras (SC)	1,7	1,6	1,5	1,4	1,3
Tanah Sedang (SD)	2,4	2,0	1,8	1,6	1,5
Tanah Lunak (SE)	3,5	3,2	2,8	2,4	2,4
Tanah Khusus (SF)	SS	SS	SS	SS	SS

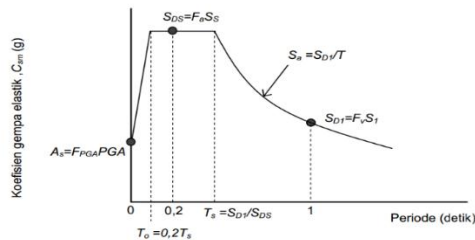
PGA = percepatan puncak batuan dasar mengacu pada Peta Gempa Indonesia 2010

Ss = parameter respons spektral percepatan gempa untuk periode pendek ($T=0.2$ detik) mengacu pada Peta Gempa Indonesia 2010

SS = lokasi yang memerlukan investigasi geoteknik dan analisis respons dinamik spesifik

S1 = parameter respons spektral percepatan gempa untuk periode 1 detik mengacu pada Peta Gempa Indonesia 2010

iii. Respon Spektrum Rencana



Gambar 2. 15 Spektrum rencana gempa (2016)

Perumusan desain respon spektrum adalah sebagai berikut :

$$A_s = F_{PGA} \times PGA$$

$$S_{DS} = F_a \times S_s$$

$$S_{D1} = F_v \times S1$$

a. Bangunan Atas

Kontrol kekuatan struktur utama dilakukan setelah pemodelan struktur dan didapatkan gaya dalam dalam masing-masing elemen struktur utama. Kontrol kekuatan struktur dilakukan berdasarkan dimensi yang telah ditentukan pada *preliminary design*. Apabila hasil kontrol elemen kekuatan struktur menunjukkan elemen tersebut tidak memenuhi syarat, maka dilakukan desain ulang pada *preliminary*.

i. **Perhitungan Struktur Baja**

Perhitungan komponen struktur baja pada desain *jembatan cable-stayed* ini mengacu pada RSNI 03-2005.

Sifat-sifat mekanis baja struktural yang dibutuhkan dalam perencanaan struktur baja adalah sebagai berikut:

Modulus elastisitas	:	$E = 200.000 \text{ MPa}$
Modulus geser	:	$G = 80.000 \text{ MPa}$
Angka <i>poisson</i>	:	$\mu = 0,3$
Koefisien pemuaian	:	$\alpha = 12 \times 10^{-6} \text{ per } ^\circ\text{C}$
Jenis Baja	:	BJ50

a. Gelagar Melintang dan Memanjang

Gelagar memanjang berfungsi menyalurkan beban kendaraan pada pelat beton ke gelagar melintang. Sedang galagar melintang menyalurkan beban dari gelagar memanjang ke gelagar utama. Pembebanan yang digunakan mengacu pada SNI 1725 2016. Untuk profil yang digunakan pada gelagar memanjang dan melintang adalah profil WF yang dikontrol dengan acuan RSNI 03-2005.

1. Kontrol Kapasitas Lentur

$$\phi M_n > M_u$$

2. Kontrol Kapasitas Geser

$$V_n \leq 0,6 F_y A_w C_v$$

Berdasarkan RSNI 03-2005 G2.1 (b) untuk badan dari semua profil simetris ganda dan profil simetris

tunggal serta kanal lainnya, kecuali PSB bundar, koefisien geser badan, C_v , ditentukan sebagai berikut :

(i) Bila $h / t w \leq 1,10 \sqrt{k v E / F y}$

$$C_v = 1,0$$

(ii) Bila $1,10 \sqrt{k v E / F y} < h / t w < 1,37 \sqrt{k v E / F y}$

$$C_v = \frac{1,10 \sqrt{k v E / F y}}{h / t w}$$

(iii) Bila $h / t w \geq 1,37 \sqrt{k v E / F y}$

$$C_v = \frac{1,51 K v E}{h / t w^2 F y}$$

3. Kontrol Lendutan

Menurut RSNI T 03 2005 lendutan maksimum gelagar diantara dua tumpuan.

b. Gelagar Utama

Gelagar utama ini dianalisa untuk mengetahui kemampuan *box girder* terhadap gaya yang bekerja. Kontrol gelagar utama mengacu pada RSNI 03-2005. Kontrol akibat aksial digunakan persamaan berikut :

$$\phi P_n > P_{u_{\max}}$$

ii. Perhitungan Struktur Beton

Perhitungan struktur beton untuk *pylon* mengacu pada SNI T 12 2004. *Pylon* didesain dengan mempertimbangkan gaya aksial dan lentur menggunakan metode interaksi.

a. Analisa Struktur Tekan

Desain kekuatan lentur dan aksial komponen struktur tekan pada *pylon* dijelaskan dalam Pasal 5.3.3 SNI T 12 2004 sebagai berikut:

$$\phi P_{n(max)} = 0,8\phi[0,85f'_c(A_g - A_{st} + f_y A_{st})]$$

Dalam perencanaan momen lentur minimum harus diambil tidak kurang dari $0,05h N_u$ sesuai Pasal 5.7.3 SNI T 12 2004.

Sedangkan dalam perencanaanya kolom dibagi menjadi dua jenis, yaitu kolom pendek dan kolom langsing. Pengelompokan tersebut dijelaskan dalam Pasal 5.7.6 SNI T 12 2004. Pengaruh kelangsingan dapat diabaikan apabila persamaan berikut terpenuhi.

$$\frac{kl_u}{r} < 22$$

Dengan,

l_u : panjang bebas komponen tekan

r : jari-jari girasi penampang kolom = $\sqrt{\frac{I_x}{A}}$

k : faktor panjang efektif (ditentukan dengan gambar berikut)

Tabel 2. 5 Faktor panjang efektif

TABLE C-A-7.1 Approximate Values of Effective Length Factor, K						
Buckled shape of column is shown by dashed line	(a)	(b)	(c)	(d)	(e)	(f)
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.1	2.0
End condition code	Rotation fixed and translation fixed Rotation free and translation fixed Rotation fixed and translation free Rotation free and translation free					

Pada kolom langsing, faktor perbesaran momen harus diperhitungkan dengan mengelompokkan kolom menjadi kolom bergoyang dan tidak bergoyang. Kolom dianggap tak bergoyang apabila nilai dari persamaan berikut terpenuhi.

$$Q = \frac{\sum P_u \Delta_o}{V_u l_c} < 0,05$$

Dengan,

ΣP_u : jumlah beban vertikal terfaktor pada tingkat yang ditinjau

V_u : gaya geser total pada tingkat yang ditinjau

Δ_o : simpangan relatif antar tingkat orde-pertama akibat V_u

i. Kolom Tak Bergoyang

Untuk struktur tak bergoyang, perbesaran momen dihitung berdasarkan Pasal 5.7.6.1 SNI T 12 2004 sebagai berikut:

$$M_c = \delta_{ns} \cdot M_2$$

Dengan,

M_c : momen terfaktor ang diperbesar

M_2 : momen terfaktor

δ_{ns} : faktor perbesaran mome yang dihitung sebagai berikut

$$\delta_{ns} = \frac{C_m}{1 - \frac{P_u}{0,75P_c}} > 1,0$$

Untuk komponen struktur yang tak bergoyang dan tanpa beban transversal di antara tumpuan, maka C_m diambil sebagai berikut:

$$C_m = 0,6 + 0,4 \left(\frac{M_1}{M_2} \right) > 0,4$$

Untuk komponen struktur dengan beban transversal C_m diambil sama dengan 1,0.

ii. Kolom Bergoyang

Untuk struktur bergoyang, perbesaran momen dihitung berdasarkan Pasal 5.7.6.2 SNI T 12 2004 sebagai berikut:

Momen M_1 dan M_2 pada ujung-ujung komponen struktur tekan harus diambil sebesar:

$$M_1 = M_{1ns} + \delta_s M_{1s}$$

$$M_2 = M_{2ns} + \delta_s M_{2s}$$

Nilai $\delta_s M_s$ dihitung sebagai berikut:

$$\delta_s M_s = \frac{M_s}{1-Q} \geq M_s$$

Apabila $\delta_s M_s$ yang dihitung lebih dari 1,5, maka $\delta_s M_s$ dihitung dengan persamaan berikut:

$$\delta_s M_s = \frac{M_s}{1 - \frac{\sum P_u}{0,75 \sum P_c}} \geq M_s$$

Untuk mempermudah analisis perhitungan tulangan kolom digunakan program bantu SpColum.

b. Peryaratan Tulangan Memanjang Kolom

Ketentuan luas tulangan memanjang kolom diatur dalam Pasal 5.7.8.1 SNI T 02 2004 sebagai berikut:

$$0,01A_g \leq A_{st} \leq 0,08A_g$$

Jarak bersih minimum antar tulangan sejajar, seikat tulangan dan sejenisnya tidak boleh kurang dari:

- 1,5 kali ukuran nominal maksimum agregat.
- 1,5 kali diameter tulangan.
- 40 mm.

c. Ketentuan Tulangan Sengkang

Ukuran tulangan sengkang atau spiral tidak boleh kurang dari ketentuan berikut:

Jarak antara sengkang atau spiral tidak melebihi harga terkecil dari:

- h_c atau $15 d_b$ untuk tulangan tunggal.
- $0,5 h_c$ atau $7,5 d_b$ untuk tulangan kelompok.
- 300 mm.

d. Desain Tulangan Geser *Pylon*

Kekuatan geser untuk struktur *pylon* direncanakan sebagai berikut:

$$V_u \leq \phi V_n$$

Kekuatan geser nominal dihitung sebagai berikut:

$$V_n = V_c + V_s$$

V_c pada struktur yang dibebani tekan aksial dihitung sebagai berikut:

$$V_c = \left(1 + \frac{N_u}{14A_g}\right) \left(\frac{\sqrt{f'_c}}{6}\right) \cdot bw \cdot d$$

Sedangkan kekuatan geser tulangan V_s dihitung sebagai berikut:

$$V_s = \frac{A_v f_y d}{s}$$

Jarak antar tulangan geser maksimum ditentukan sebagai berikut:

- $S_{\max} = d/2$ atau 600 mm (diambil nilai terkecil)
bila $V_s \leq \frac{1}{3} \sqrt{f'_c} bw \cdot d$
- $S_{\max} = d/4$ atau 300 mm (diambil nilai terkecil)
bila $V_s > \frac{1}{3} \sqrt{f'_c} bw \cdot d$

e. Desain Tulangan Torsi *Pylon*

Pengaruh torsi dapat diabaikan apabila momen torsi terfaktor kurang dari:

$$\phi 0,083 \lambda \sqrt{f'_c} \left(\frac{A_{cp}^2}{p_{cp}} \right) \sqrt{1 + \frac{N_u}{0,33 A_g \lambda \sqrt{f'_c}}}$$

Dimensi penampang untuk struktur yang dibebani torsi harus memenuhi persyaratan berikut:

$$\sqrt{\left(\frac{V_u}{b_w d}\right)^2 + \left(\frac{T_u p_h}{1,7 A_{oh}^2}\right)^2} \leq \left(\frac{V_c}{b_w d} + 0,66 \sqrt{f'_c}\right)$$

Apabila diperlukan tulangan torsi, maka kuat rencana torsi dihitung sebagai berikut:

$$\phi T_n \geq T_u$$

Kuat torsi nominal T_n dihitung sebagai berikut:

$$T_n = \frac{2 A_o A_t f_{yt}}{s} \cot \theta$$

Nilai A_o diambil sebesar $0,85 A_{oh}$, di mana A_{oh} merupakan luasan yang dibatasi oleh tulangan sengkang tertutup. Sedangkan θ diambil sebesar 45° .

Luas tulangan longitudinal tambahan untuk tulangan torsi, A_l , diambil sebesar:

$$A_t = \frac{A_t}{s} p_h \left(\frac{f_{yt}}{f_y} \right) \cot^2 \theta$$

b. Bangunan Bawah

- **Pondasi Tiang Pancang Tunggal**

Sebelum merencanakan pondasi tiang pancang, kita harus menentukan daya dukung suatu tiang. Salah satu rumus yang dapat digunakan adalah *spring constant* nakazawa.

- **Daya Dukung Vertikal**

$$K_v = 0,2 \cdot E_o \cdot D^{-0,75} \cdot A$$

Dengan :

K_v = daya dukung vertikal (T/m)

E_o = 28 N (N = jumlah SPT tiap 1 m) (kg/cm^2)

D = diameter tiang pancang (cm)

A = luas permukaan tiang pancang (cm^2)

- **Daya Dukung Horizontal**

$$K = 0,2 \cdot E_o \cdot D^{-0,75} \cdot y^{-0,75}$$

$$K_x = K_y = K \cdot D \cdot Dz$$

Dengan :

Y = tinjauan per 1 cm

Dz = kedalaman tinjauan (m)

- **Gaya Geser Dinding Tiang**

$$R_f = U \times \Sigma(l_i \times f_i)$$

Dengan : R_f = gaya geser dinding tiang (ton)

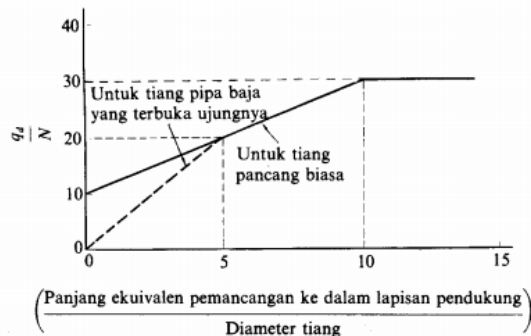
U = keliling tiang (m)

l_i = Tebal lapisan tanah dengan memperhitungkan geseran dinding tiang

f_i = Besarnya gaya geser maksimum dari lapisan tanah dengan memperhitungkan geseran dinding tiang (ton/m^2)

- **Daya Dukung Ujung Tiang**

Untuk daya dukung terpusat tiang dapat dicari dengan table di bawah ini :



Gambar 2. 16 Diagram Perhitungan Intensitas Daya Dukung Ultimate Tanah Pondasi Pada Ujung Tiang

Setelah menentukan diameter tiang pancang dan panjang penetrasi tiang sampai ke lapisan pendukung sudah di dapat maka q_d dapat dicari.

$$R_p = q_d \times A$$

Dengan : R_p = daya dukung ujung tiang (ton)

q_d = daya dukung terpusat tiang (ton)

A = luas ujung tiang (m^2)

- **Daya Dukung Ultimate Tiang**

$$R_u = R_p + R_f$$

Dengan : R_u = daya dukung ultimate tanah pondasi (ton)

R_f = gaya geser dinding tiang (ton)

R_p = daya dukung ujung tiang (ton)

- **Daya Dukung Ijin Tiang**

$$R_a = \frac{R_u}{SF}$$

Dengan : SF = safety factor

Tabel 2. 6 Faktor Keamanan

	Jembatan jalan raya		Jembatan kereta api	Konstruksi pelabuhan	
	Tiang pendukung	Tiang geser	—	Tiang pendukung	Tiang geser
Beban tetap	3	4	3	Lebih besar dari 2,5	
Beban tetap + Beban sementara	—	—	2	—	
Waktu gempa	2	3	1,5 (1,2)	Lebih besar dari 1,5	Lebih besar dari 2,0

Angka dalam tanda kurung: Bila beban kereta api diperhitungkan

- **Daya Dukung Mendatar Yang Diijinkan**

$$k = k_0 \cdot y^{-\frac{1}{2}}$$

$$k_0 = 0,2 \cdot E_0 \cdot D^{-\frac{3}{4}}$$

$$\beta = \sqrt[4]{\frac{k \cdot D}{4EI \text{ (cm}^{-1}\text{)}}}$$

$$H_a = \frac{k \cdot D}{\beta} \cdot \delta_a$$

Dengan :

- k = Koeffisien reaksi lapisan tanah di bawah permukaan dalam arah vertikal (kg/m^3)
- y = besarnya pergeseran yang akan dicari (cm)
- E_0 = modulus deformasi tanah pondasi, biasanya diperkirakan dari $E_0 = 28 \text{ N}$
- D = diameter tiang (cm)
- EI = Kekakuan lentur dari tiang (kg/cm^{-1})
- H_a = Daya dukung mendatar yang diijinkan (kg)
- δ_a = besar pergeseran normal (cm)

- **Pondasi Tiang Pancang Kelompok**

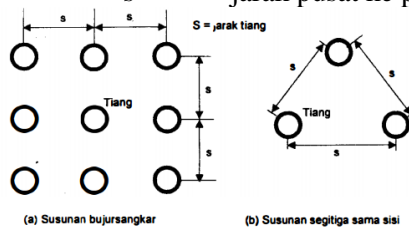
Perencanaan pondasi tiang pancang kelompok bertujuan untuk mendapatkan daya dukung yang lebih besar dari tiang tunggal.

$$Q_{\text{kel}} = Q_{\text{ijin}} \cdot 1 \text{ tiang} \cdot \text{efisiensi}$$

Perhitungan efisiensi tiang menurut Converse-Labarre Formula:

$$E_g = 1 - \theta \frac{(n'-1)m + (m-1)n'}{90 mn'}$$

Dengan : E_g = efisiensi kelompok tiang
 m = jumlah baris tiang
 n = jumlah tiang dalam satu baris
 θ = arc tg d/s , dalam derajat
 s = jarak pusat ke pusat tiang



Gambar 2. 17 Bentuk susunan tiang pancang
 Beban aksial pada tiang:

$$Q_i = \frac{V}{n} \pm \frac{M_y x_i}{\sum x^2} \pm \frac{M_x y_i}{\sum y^2} < Q \text{ ijin 1 tiang dalam kelompok}$$

$$M_y = e_x V \text{ dan } M_x = e_y V$$

Dengan :

Q_i = beban aksial pada tiang ke- i
 n = jumlah tiang
 V = jumlah beban vertical yang bekerja pada pusat kelompok tiang
 x, y = berturut-turut jarak tiang terhadap sumbu x dan y
 M_x, M_y = berturut-turut momen terhadap sumbu x dan y
 e_x, e_y = berturut-turut eksentrisitas resultan beban searah sumbu x dan y

2.4 Analisa Dinamis Struktur

Analisa dinamis struktur dilakukan untuk mengetahui stabilitas struktur jembatan akibat hembusan angin. Analisa dinamis struktur akan memberikan indikasi apakah dimensi elemen struktur sudah cukup stabil akibat perilaku dinamis struktur.

2.4.1 Frekuensi Alami

a. Frekuensi Lentur

$$f_B = \frac{1}{2\pi} \left(\frac{g}{v_{maks}} \right)^{1/2}$$

Walther (1988) menyarankan untuk meningkatkan nilai persamaan sebesar 10% karena faktor error dalam perhitungan. Sebagai taksiran yang lebih ideal, dengan memperhitungkan distribusi massa sepanjang dek, maka didapatkan:

$$f_B = \frac{1.1}{2\pi} \left(\frac{g}{v_{maks}} \right)^{1/2}$$

b. Frekuensi Torsi

i. Rantai Kendaraan Fleksibel

$$f_T = \frac{\bar{b}}{2 \cdot r} \cdot f_B$$

Di mana,

b : jarak melintang penopang (kabel)

r : jari-jari girasi gelagar rantai = $\sqrt{\frac{I}{A}}$

ii. Rantai Kendaraan Kaku

$$f_T = \frac{1}{2L} \left(\frac{G \cdot J_t}{J_p} \right)^{1/2}$$

Di mana,

J_p : inersia polar per satuan panjang rantai kendaraan

J_t : konstanta torsi

$G \cdot J_t$: kekakuan torsi penampang rantai kendaraan

L : bentang utama jembatan

2.4.2 Perilaku Aerodinamis

Dalam Peraturan PU Nomor 08/SE/M/2015 menyatakan bahwa untuk jembatan bentang panjang perlu dilakukan Uji Terowongan Angin untuk melakukan analisa efek angin yang bekerja. Ada 3 jenis Uji Terowongan Angin, diantaranya adalah *Static Section Model Test*, *Dynamic Section Model Test*, *Full Model Test*. Namun untuk keperluan tugas akhir ini tidak dilakukan Uji Terowongan Angin.

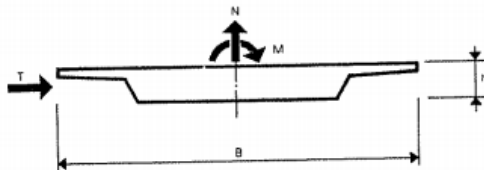
Angin menyebabkan struktur mengalami osilasi lentur dan torsi. Angin lateral membuat sudut terhadap horizontal sehingga menimbulkan efek angkat.

Menurut Walther (1988), beban hembusan angin terhadap gelagar lantai kendaraan menyebabkan penampang lantai kendaraan mengalami beban statis yang dibagi menjadi tiga, diantaranya:

- Beban horizontal T
- Beban vertikal N
- Beban torsi M

Beban-beban tersebut bergantung pada faktor berikut:

- Tekanan angin q
- Bentuk penampang (koefisien C_T , C_N dan C_M)
- Sudut insidensi angin pada dek α



Gambar 2. 18 23 Efek angin pada penampang lantai kendaraan
(Walther 1988)

$$T = C_T \cdot q \cdot h \cdot l$$

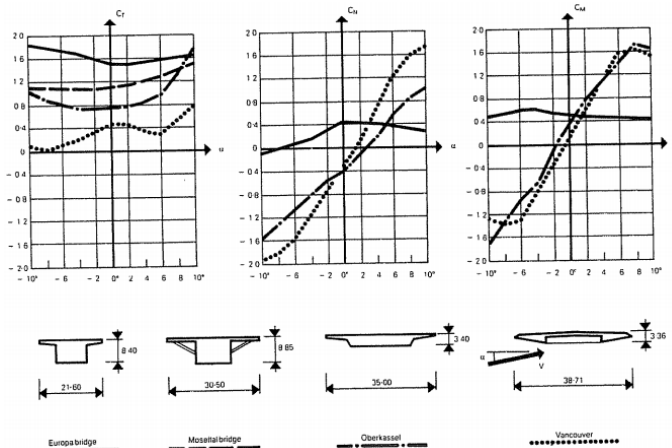
$$N = C_N \cdot q \cdot h \cdot l$$

$$M = C_M \cdot q \cdot B \cdot h \cdot l$$

Di mana,

l : panjang struktur
 h : tinggi total lantai kendaraan
 B : lebar lantai kendaraan

Koefisien CT, CN, CM didapatkan dengan melihat grafik hubungan antara bentuk gelagar dengan arah sudut angin berikut:



Gambar 2. 19 Grafik koefisien CT, CN, CM (Walther 1988)

2.4.3 Osilasi Gaya Akibat Pusaran Angin (Vortex Shedding)

Kecepatan angin yang berhembu pada lantai kendaraan dihitung menggunakan angka Strouhal:

$$S = \frac{f \cdot h}{V}$$

Di mana,

f : frekuensi pusaran

h : tinggi lantai kendaraan

S : 0,20 untuk silinder dengan diameter h

: 0,10 – 0,20 untuk lantai kendaraan dengan tinggi h

: 1,10 jika udara mengalir pada satu sisi

V: kecepatan angin

Kemudian dicek dengan angka Reynold harus memenuhi persyaratan berikut dengan $Re = 10^5$ s/d 10^7 :

$$Re = \frac{V \cdot B}{\bar{\nu}}$$

Di mana,

V : kecepatan angin dihitung berdasarkan angka Strouhal

B : lebar lantai kendaraan

$\bar{\nu}$: viskositas kinemati udara (0,15 cm²/detik)

akibat terpaan angin, akan terjadi gaya uplift atau gaya angkat yang besarnya

$$F_o = \frac{\rho \cdot V^2}{2} \cdot c \cdot h$$

Di mana,

ρ : densitas udara = 1,3 kg/m³

c : koefisien gaya angkat penampang, tergantung f dan V

h : tinggi lantai kendaraan

Gaya ini menimbulkan amplitudo Akibat Osilasi, v

$$v = \frac{\pi}{\delta} \cdot \frac{F_o}{m} V_{maks}$$

Di mana,

δ : penurunan logaritmik (damping ratio) = 0,05

Fo : gaya angkat

Vmaks : Deformasi statis maksimum struktur karena berat sendiri dalam arah yang ditinjau

m : Berat sendiri lantai kendaraan per meter lari

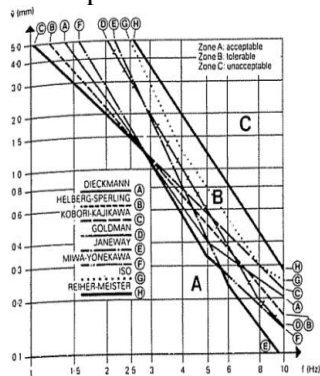
Bila perlu, perhitungan dapat dilanjutkan dengan menghitung percepatan Akibat Osilasi, \ddot{v}

$$\ddot{v} = 4 \cdot \pi^2 \cdot f^2 \cdot v$$

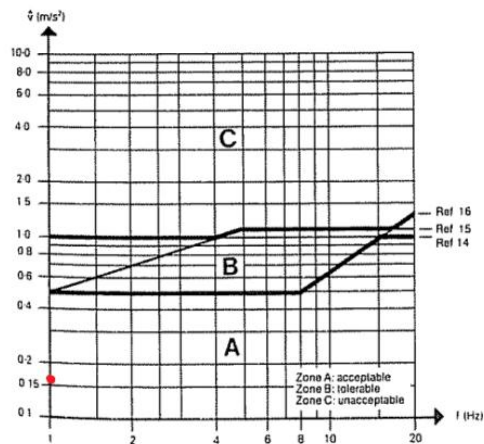
f : Frekuensi alami = f_B

Setelah dilakukan perhitungan amplitudo akibat osilasi dan juga percepatan akibat osilasi, kemudian diplotkan dalam grafik di bawah untuk mengetahui keamanan struktur jembatan akibat osilasi. Pertama, nilai amplitudo dan frekuensi lentur yang telah dihitung diplotkan dalam grafik, apabila hasil plot berada di zona A maka struktur aman terhadap osilasi. Kemudian, nilai percepatan dan frekuensi torsi diplotkan pada grafik, apabila hasil plot berada pada zona A maka struktur aman terhadap osilasi. Kedua tolak

ukur tersebut harus dipenuhi untuk menjamin keamanan struktur jembatan terhadap osilasi.



Gambar 2. 20 Klasifikasi efek psikologis berdasarkan amplitudo (Walther 1988)



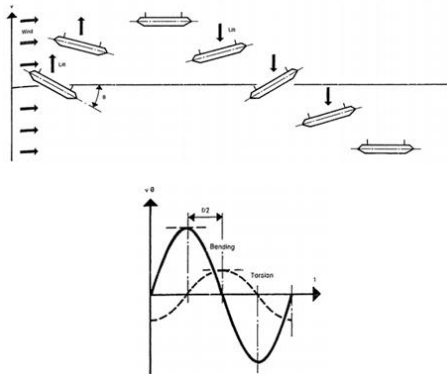
Gambar 2. 21 Klasifikasi psikologis berdasarkan percepatan (Walther 1988)

Diharapkan nilai v dan \ddot{v} kecil agar tidak menimbulkan efek psikologis. Untuk meminimalisasi vortex-shedding ini, dapat diambil langkah (Walther,1999):

- Memberikan lantai kendaraan penampang yang lancip di tepinya untuk membelah angin. Dengan cara itu tidak terjadi turbulensi.
- Memasang *deflector* atau pengarah angin disudut-sudut penampang

2.4.4 Efek Flutter

Flutter terjadi jika muncul ayunan lentur dan ayunan torsi akibat terpaan angin pada kecepatan kritis. Gabungan antara ayunan lentur dan ayunan torsi ini semakin lama akan semakin besar walaupun kecepatan kritis tetap dan akan menyebabkan runtuhnya struktur. (Walther, 1999). Yang harus dihindari amplitudo akibat lentur dan torsi tidak terjadi bersamaan, yang ideal berjarak $t = \frac{\mu}{2} = 1,57$ detik seperti pada gambar berikut.



Gambar 2. 22 Representasi sederhana flutter pada dek jembatan (Walther 1988)

Nilai $V_{\text{kritis teoritis}}$ tersebut didapatkan dari grafik berikut tergantung dari 3 besaran:

$$\mu = \frac{m}{\pi \cdot \rho \cdot b^2} \quad \varepsilon = \frac{f_T}{f_B} \quad \frac{\delta}{b}$$

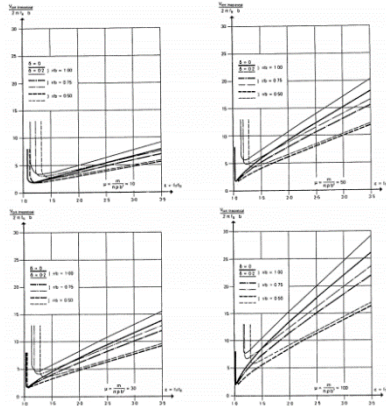
$$V_{\text{critic.theoritic}} = 2 \cdot \pi \cdot f_B \cdot b$$

Dimana :

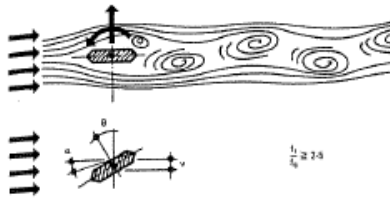
b : $\frac{1}{2}$ lebar lantai kendaraan

m : serat sendiri lantai kendaraan per meter lari

p : densitas udara = $1,3 \text{ kg/m}^3$



Gambar 2. 23 Kecepatan teoritis untuk flutter (Walther 1988)



Gambar 2. 24 Contoh fenomena Flutter

Kecepatan kritis teoritis yang didapatkan dari grafik di atas kemudian harus dikoreksi dengan nilai η yang didapatkan dari grafik di bawah sehingga didapatkan kecepatan kritis aktual.

Pada kondisi nyata, angin yang berhembus ke lantai jembatan tidak selalu tepat horizontal secara sempurna. Terkadang nilai α dapat berubah antara 3° sampai 9° , maka diambil nilai α rata-rata sebesar 6° . Maka nilai koreksi tadi harus dikoreksi lagi sehingga:

Untuk penampang *box*:

$$\frac{\eta(\alpha = \pm 6^\circ)}{\eta(\alpha = 0)} = \frac{1}{3}$$

Setelah didapatkan kecepatan kritis aktual, nilai tersebut dibandingkan dengan kecepatan angin pada kondisi lapangan. Kecepatan angin kondisi lapangan harus lebih kecil dari kecepatan kritis aktual dari perhitungan.

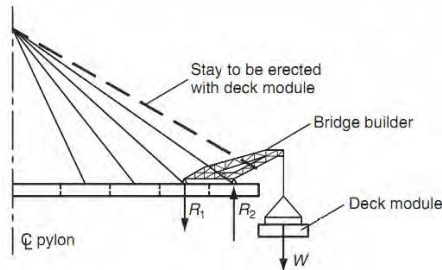
$$V_{lapangan} \leq V_{actual\ kritis}$$

2.5 Metode Pelaksanaan

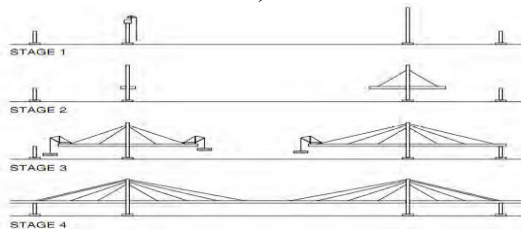
1. Pekerjaan Persiapan :
 - a. Pembuatan jalan kerja
 - b. Pembuatan lokasi unloading material
2. Pekerjaan Pembersihan Lahan
 - Pengukuran menggunakan alat (theodolite, waterpass, dll.)
 - Pembuatan direksi kit
3. Mobilisasi
 - Mobilisasi material
 - Mobilisasi alat berat
 - Mobilisasi tenaga kerja
4. Pekerjaan Pondasi
 - Pekerjaan pengeboran
 - Pekerjaan pembesian
 - Pekerjaan pengecoran
5. Pekerjaan pile cap
 - Pekerjaan pembesian
 - Pemasangan bekisting
 - Pekerjaan pengecoran
6. Pekerjaan pylon
 - Pekerjaan pembesian
 - Pemasangan bekisting
 - Pekerjaan pengecoran
7. Pekerjaan Bangunan Atas
 - Pekerjaan Pemasangan *twin steel box girder* dan kabel

a. Bangunan Atas

Metode balanced cantilever adalah metode pelaksanaan konstruksi jembatan ini, dimana satu bentang jembatan dikerjakan sampai selesai dengan bantuan traveler crane, kemudian berlanjut ke bentang berikutnya. Proses tersebut berulang sampai seluruh bentang jembatan tersambung.



Gambar 2. 25 Metode pelaksanaan kantilever (Parke and Huson, 2008)



Gambar 2. 26 Metode pelaksanaan kantilever (Gimsing dan T.Christos , 2012)

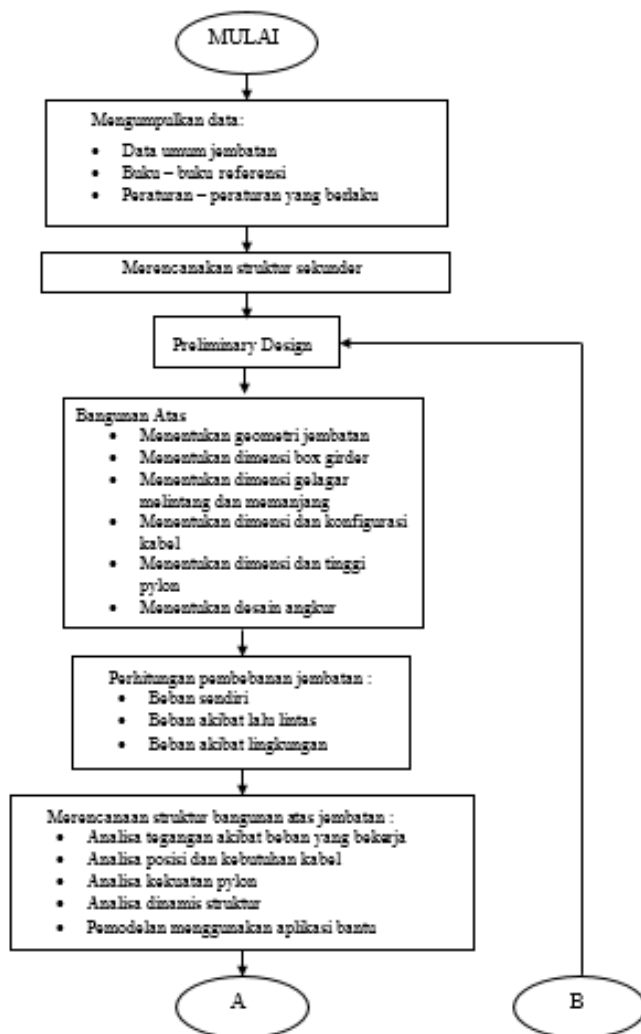
b. Bangunan Bawah

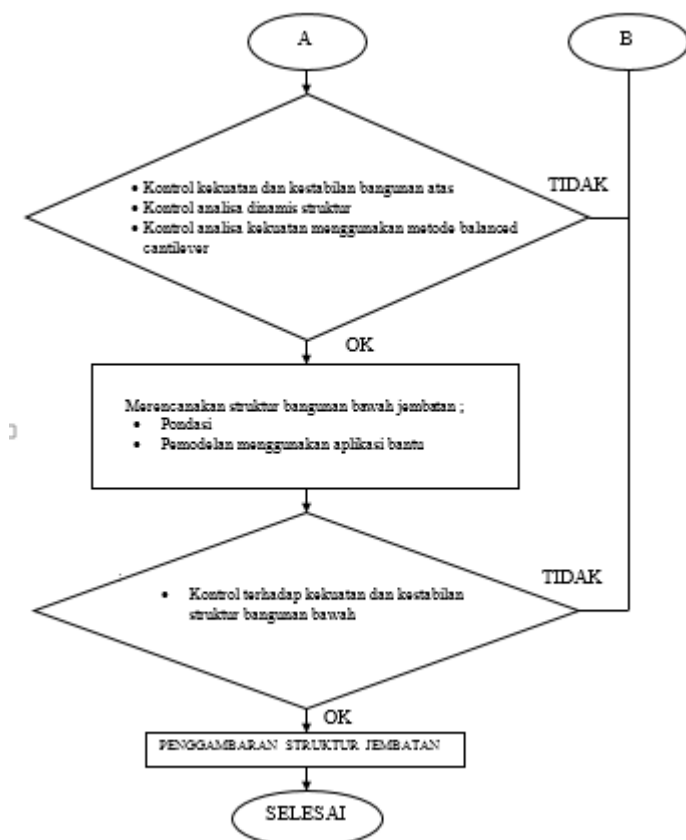
Pondasi *Bored Pile* adalah pondasi yang digunakan dalam merencanakan jembatan ini. Pondasi *bored pile* dibangun dengan cara mengebor tanah terlebih dahulu, baru kemudian diisi dengan tulangan dan dicor.

BAB III

METODOLOGI

3.1 Diagram Alir





Gambar 3. 1 Bagan Alir

3.2 Pengumpulan Data

Langkah pertama dalam melakukan pengumpulan data adalah mencari data eksisting jembatan, literatur-literatur, dan peraturan yang berkaitan dengan jembatan *cable-stayed*.

- **Data umum jembatan**

Data yang digunakan dalam perencanaan jembatan adalah:

1. Panjang jembatan : 144 meter
2. Lebar jembatan : 20,5 meter
3. Lantai kendaraan : 2 lajur 2 arah, lebar 17,5 meter

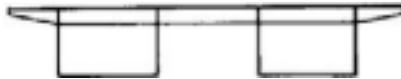
3.3 Preliminary Design

3.3.1 Preliminary Design Gelagar

Dalam Pasal 4.6.2 Peraturan PU Nomor 08/SE/M/2015 dijelaskan tentang estimasi awal tinggi gelagar utama dapat ditetentukan $1/50 - 1/70$ dari panjang bentang utama.

$$\text{Tinggi gelagar utama } \frac{L}{40} > h > \frac{L}{70} \dots (3.1)$$

Bentuk gelagar utama jembatan ini di deasin menggunakan *twin rectangular box* seperti pada gambar.



Gambar 3. 2 Gelagar jenis twin box girder

3.3.2 Preliminary Design Kabel

a. Konfigurasi Susunan Kabel

Susunan kabel memanjang digunakan tipe *fan pattern* dan digunakan sistem *double plan*. Susunan ini lebih menguntungkan karena pemasangan kabel tidak akan serumit *radiating pattern*.



Gambar 3. 3 Konfigurasi Kabel tipe fan patter



Gambar 3. 4 Posisi Kabel dengan sistem double plan

b. Jarak Antar Kabel

Dalam Pasal 4.4.3 Peraturan PU Nomor 08/SE/M/2015 dijelaskan tentang acuan jarak kabel yang umum digunakan. Dek jembatan yang terbuat dari baja atau material komposit, jarak antar kabel adalah 15 meter sampai dengan 25 meter.

c. Dimensi Kabel

Penentuan dimensi awal mengacu pada Pasal 11.1 Peraturan PU Nomor 08/SE/M/2015 sebagai berikut:

Luas penampang kabel ditentukan berdasarkan persamaan berikut:

$$A_{sc,i} \cong \frac{\left(g + p + \frac{P}{30d}\right)(\lambda_i + \lambda_{i+1})\cos\phi_i}{2(f_{cbd}\sin\phi_i\cos\phi_i - \gamma_{cb}a_1)} \quad (3.2)$$

Dengan,

$T_{sc,i}$: gaya tarik pada kabel ke i

g : beban merata mati

p : beban merata hidup

d : tinggi gelagar jembatan

P : beban terpusat

λ_i : jarak antar kabel

ϕ_i : sudut kabel ke i terhadap bidang horizontal

γ_{cb} : berat jenis kabel

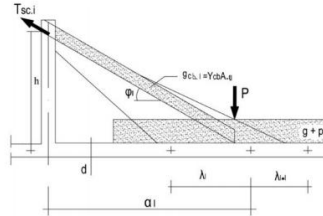
$A_{sc,i}$: luas penampang kabel ke i

f_{cbd} : tegangan ijin kabel

h : tinggi menara dari elevasi gelagar

A_{ac} : luas penampang kabel angkur

Jumlah kabel $(n) = \frac{A_{sc}}{A_s}$, A_s = luas penampang kabel



Gambar 3. 5 Gaya yang bekerja pada kabel angkur (Peraturan PU No.08/SE/M/2015)

d. Modulus Elastisitas Kabel

Berdasarkan penurunan rumus yang telah dilakukan oleh Troitsky (1977), maka didapatkan persamaan modulus elastisitas ekivalen ideal sebagai berikut:

$$E_i = \frac{E_e}{1 + \left[\frac{(\gamma L)^2}{12 \sigma^3} \right] E_e} \quad (3.3)$$

Dengan,

Ei : Modulus Young kabel ideal akibat lengkungan

Ee : Modulus Young kabel pada kondisi lurus

γ : berat jenis kabel = 77,01 kN/m³

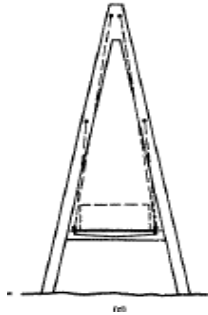
L : panjang horizontal kabel

σ : tegangan tarik kabel

3.3.3 Preliminary Design Pylon

a. Data Awal Pylon

- Material : Beton bertulang
- f_c' : 50 MPa
- f_y : 400 MPa
- Bentuk : A dengan sistem *double plane*



Gambar 3. 6 Bentuk pylon jembatan

b. Tinggi Pylon

Dalam Pasal 4.7.1 Peraturan PU Nomor 08/SE/M/2015 dijelaskan ketentuan untuk perkiraan awal tinggi *pylon* yaitu sebesar 0,19 – 0,25 dari bentang jembatan terpanjang.

c. Dimensi Awal Pylon

Ketentuan dalam penentuan dimensi awal *pylon* dijelaskan dalam Pasal 11.2.1 Peraturan PU Nomor 08/SE/M/2015. Dalam menentukan dimensi awal *pylon* dengan konfigurasi kabel arah memanjang pola *fan*, perlu dihitung perkiraan gaya maksimum yang bekerja pada *pylon* sebagai berikut:

$$N_{pt} = \frac{1}{2}(g_a + p_a)a_a + \frac{1}{2}(g_m + p_m)\left(2 + \frac{a_m}{a_a}\right)a_m + \frac{2}{3}Q_{Fa} + Q_{Fm}\left(1 + \frac{a_m}{3a_a}\right) + \frac{1}{2}Q_a \quad (3.4)$$

Dengan,

Q_{Fa} : kuantitas dari kabel di bentang tepi

Q_{Fm} : kuantitas dari kabel di bentang tengah

Q_a : kuantitas kabel angkur

3.4 Analisis Pembebanan Struktur Jembatan

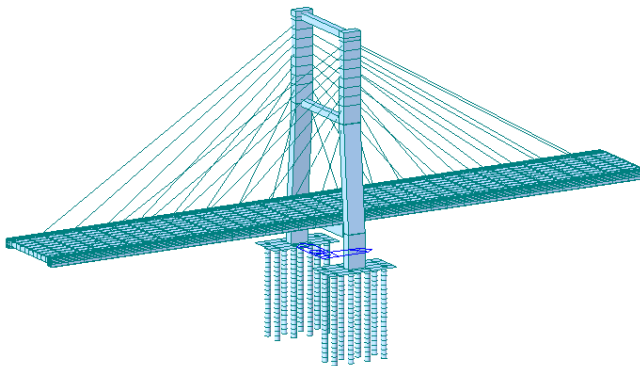
Peraturan pembebanan yang digunakan adalah peraturan SNI 1725-2016 meliputi:

1. Beban Permanen
 - a. Beban Mati
 - b. Beban Mati Tambahan
2. Beban Lalu Lintas
 - a. Beban Lajur “D”
 - b. Beban Truk
 - c. Faktor Beban Dinamis
 - d. Gaya Rem (TB)
3. Aksi Lingkungan
 - a. Beban Angin
 - b. Tekanan angin vertikal.
 - c. Pengaruh Gempa
4. Kombinasi Pembebanan

Kombinasi pembebanan untuk jembatan mengacu pada Tabel 1 SNI 1725 2016.

3.5 Permodelan Struktur

Pemodelan struktur untuk desain jembatan *cable-stayed* dilakukan menggunakan program bantu MIDAS CIVIL. Hal ini dilakukan baik untuk keperluan penentuan gaya dalam, stabilitas, maupun analisa metode pelaksanaan.



Gambar 3. 7 Permodelan 3D pada MIDAS CIVIL

3.6 Desain Struktur Sekunder

Kontrol kekuatan struktur sekunder dilakukan setelah pemodelan struktur dan didapatkan gaya dalam pada struktur sekunder. Kontrol kekuatan struktur sekunder meliputi:

- a. Desain lantai kendaraan direncanakan berupa beton komposit antara beton bertulang dengan *steel deck*.
- b. Desain parapet direncanakan dengan mengacu pada RSNI T-02-2005.

3.7 Desain Struktur Utama

a. Bangunan Atas

1. Perhitungan Struktur Baja

Perhitungan komponen struktur baja pada desain *jembatan cable-stayed* ini mengacu pada SNI 1729 2015.

2. Perhitungan Struktur Beton

Perhitungan struktur beton untuk *pylon* mengacu pada SNI T 12 2004. *Pylon* didesain dengan mempertimbangkan gaya aksial dan lentur menggunakan metode interaksi.

b. Bangunan Bawah

1. Pondasi Tiang Pancang Tunggal

Sebelum merencanakan pondasi tiang pancang, kita harus menentukan daya dukung suatu tiang. Salah satu rumus yang dapat digunakan adalah *spring constant* nakazawa.

2. Pondasi Tiang Pancang Kelompok

Perencanaan pondasi tiang pancang kelompok bertujuan untuk mendapatkan daya dukung yang lebih besar dari tiang tunggal.

3.8 Desain Angkur

Desain angkur kabel dilakukan pada gelagar dan *pylon*. Angkur pada gelagar didesain sebagai angkur hidup sedangkan pada *pylon* didesain sebagai angkur mati. Desain angkur meliputi kontrol kebutuhan tebal pelat angkur pada gelagar.

3.9 Analisa Dinamis Struktur

Analisa dinamis struktur dilakukan untuk mengetahui stabilitas struktur jembatan akibat hembusan angin. Analisa dinamis struktur akan memberikan indikasi apakah dimensi elemen struktur sudah cukup stabil akibat perilaku dinamis struktur. Kontrol dinamis struktur meliputi:

- a. Frekuensi Alami
- b. Osilasi Gaya Akibat Pusaran Angin (Vortex Shedding)
- c. Efek Flutter

3.10 Penggambaran Layout dan Detail Struktur Jembatan

Setelah semua analisa dan perhitungan selesai dilakukan, maka berikutnya dilakukan penggambaran detail jembatan *cable-stayed* sesuai dengan hasil analisa dan perhitungan tersebut. Penggambaran dikerjakan dengan program bantu AutoCAD.

(halaman ini sengaja dikosongkan)

BAB IV

PRELIMINARY DESAIN

Sebelum melakukan perhitungan struktur sekunder dan permodelan struktur, perlu dilakukan perkiraan dimensi awal yang mengacu pada referensi. Dimensi awal yang perlu ditaksirkan ialah susunan kabel, dimensi gelagar, kabel dan *pylon*, yang akan digunakan sebagai data awal dalam analisa struktur.

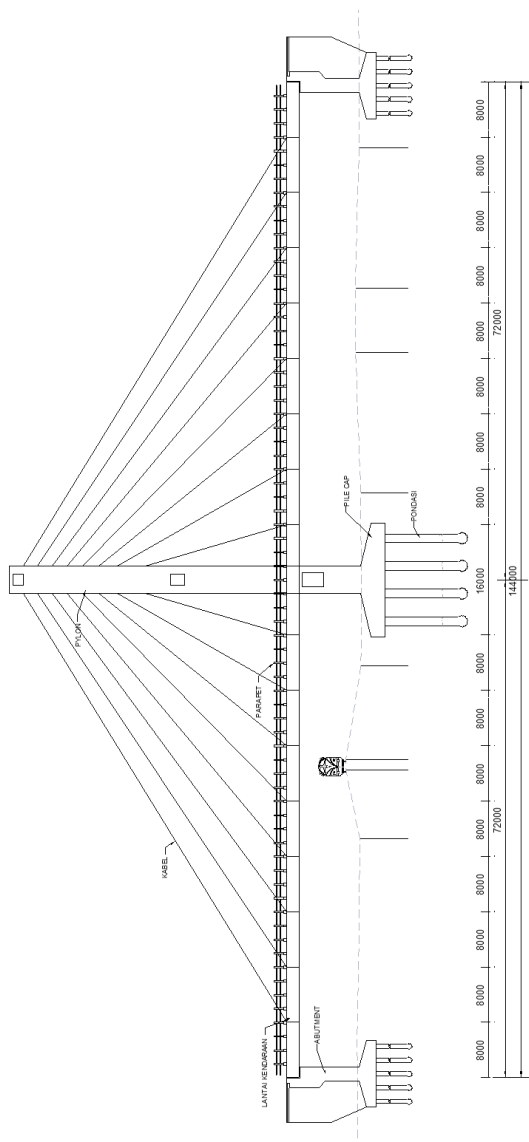
4.1 Preliminary Desain

4.1.1 Konfigurasi Susunan Kabel

Konfigurasi susunan kabel pada arah melintang berupa *Double Planes System*, sedangkan untuk arah memanjang berupa *Fan Pattern* dengan detail sebagai berikut

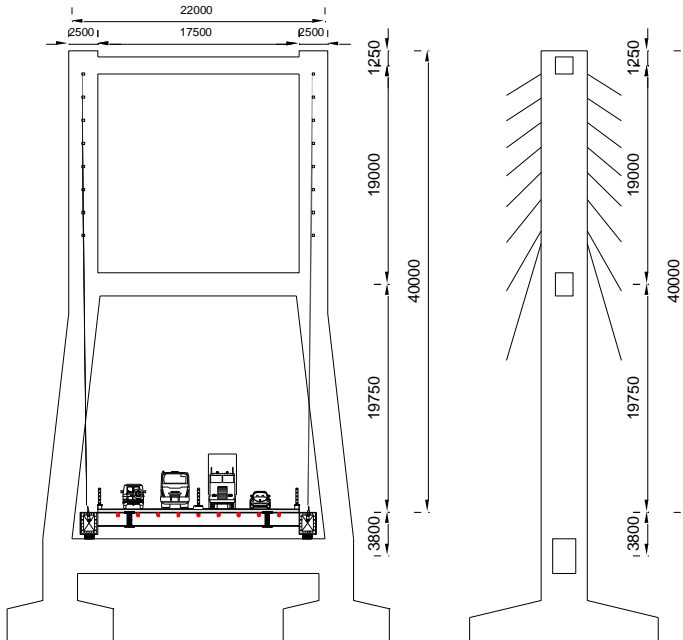
- 1) Jarak kabel pada gelagar menurut dalam Pasal 4.4.3 Peraturan PU Nomor 08/SE/M/2015 :
Untuk gelagar baja (15 m – 25 m) dipakai
Pada desain ini dipakai jarak kabel pada gelagar 8 m seperti pada gambar 4.1.
- 2) Tinggi *pylon* (h), menurut Dalam Pasal 4.7.1 Peraturan PU Nomor 08/SE/M/2015 dapat diperkirakan awal tinggi *pylon* yaitu sebesar 0,19 – 0,25 dari bentang jembatan terpanjang.
$$0.19L < H < 0.25L$$
$$0.19 \cdot 144 < H < 0.25 \cdot 144$$
$$27,36\text{m} < H < 36\text{m}$$

Pada desain dipakai $H = 40 \text{ m}$
- 3) Jarak antar kabel pada *pylon*:
Untuk jarak antar kabel pada *pylon* dipakai 2 m.



Gambar 4. 1 *Long section* dan denah jembatan cable stayed

Berikut ilustrasi susunan kabel arah melintang jembatan, dapat dilihat pada Gambar 4.2.



Gambar 4. 2 Susunan Kabel Arah Melintang Berupa Double Planes System (dalam milimeter)

4.1.2 Dimensi Gelagar Utama

Dalam Pasal 4.6.2 Peraturan PU Nomor 08/SE/M/2015 dijelaskan tentang estimasi awal tinggi gelagar utama dapat ditentukan $1/50 - 1/70$ dari panjang bentang utama.

$$\text{Tinggi gelagar utama } \frac{L}{40} > h > \frac{L}{70} \dots (3.1)$$

$$= \frac{72}{40} > h > \frac{72}{70}$$

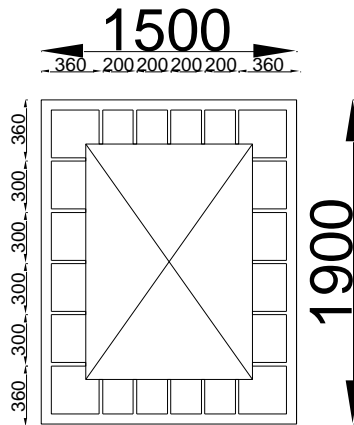
$$= 1.8\text{m} \geq h \geq 1.02\text{m}$$

Dalam desain ini, nilai tinggi *box girder* direncanakan dengan perkiraan awal dimensi *box girder* :

$$h = 1,9 \text{ m}$$

$$b = 1,5 \text{ m}$$

untuk lebih jelasnya lihat Gambar 4.3



Gambar 4. 3 Preliminary Box Girder (dalam milimeter)

4.1.3 Dimensi Gelagar Memanjang dan Melintang

1) Gelagar Memanjang

Direncanakan menggunakan profil H produk dari PT.Cigading Habeam Centre

Tinggi balok (d) $\geq (L/12)$, dimana L = panjang balok.

$$d \geq L/12$$

$$\geq 4/12 = 0,33 \text{ m}$$

Direncanakan menggunakan profil H 400.200.9.12

$$d = 400 \text{ mm} \quad tw = 9 \text{ mm}$$

$$bf = 200 \text{ mm} \quad tf = 12 \text{ mm}$$

$$r = 16 \text{ mm} \quad w = 64,9 \text{ kg/m}$$

sifat mekanis baja struktural

$$\begin{aligned} BJ &= 50 \\ f_u &= 500 \text{ MPa} \\ f_y &= 290 \text{ MPa} \end{aligned}$$

2) Gelagar Melintang

Direncanakan menggunakan profil H produk dari PT.Cigading Habeam Centre

Tinggi balok (d) $\geq (L/9)$, dimana L = panjang balok.

$$\begin{aligned} d &\geq L/9 \\ &\geq 17,5/9 = 1,94 \text{ m} \end{aligned}$$

Direncanakan menggunakan profil *Plate Girder* 1950.400.28.16

$$\begin{aligned} d &= 1950 \text{ mm} & tw &= 16 \text{ mm} \\ bf &= 400 \text{ mm} & tf &= 28 \text{ mm} \\ r &= 18 \text{ mm} & w &= 390 \text{ kg/m} \end{aligned}$$

sifat mekanis baja struktural

$$\begin{aligned} BJ &= 50 \\ f_u &= 500 \text{ MPa} \\ f_y &= 290 \text{ MPa} \end{aligned}$$

4.1.4 Dimensi Kabel dan Anker

Menurut RSNI T-03-2005 pasal 12.6 kabel pemikul utama yang dipergunakan untuk struktur-struktur jembatan kabel dan jembatan gantung harus dibuat dari material mutu tinggi dengan kuat tarik minimum 1800 N/mm^2 .

Ada dua jenis kabel paralel *VSL 7-wire strand* yang dapat digunakan untuk jembatan kabel, lihat tabel 4.1 :

Tabel 4. 1 Mutu kabel

Standard	ASTM A 416-05	Euronorme 138-3
	Grade 270	
\emptyset (mm)	15,2	15,7
A_s (mm ²)	140	150
f_u ($f_{ijin}=0,7f_u$)(Mpa)	1860 (1302)	1770 (1239)
Ukuran anker	7, 12, 19, 31, 37, 61, dan 91 strand	

Dalam desain ini digunakan kabel tipe ASTM A 416-06 Grade 270.

Dead Load (DL)

SEM PU No.08/SE/M/2015 Pasal 4.6.3 memberikan acuan estimasi awal berat gelagar jembatan. Untuk gelagar box baja dapat ditentukan dalam kisaran 2,5 s/d 3,5 kN/m². Maka ditentukan berat estimasi awal *box girder* sebesar 3,0kN/m²

$$\begin{aligned}\text{Berat girder baja} &= 300 \text{ Kg/m} \cdot 8\text{m} \cdot 1,1 \\ &= 2640 \text{ Kg} \\ \text{Berat pelat beton} &= 0,25\text{m} \cdot 2400\text{Kg/m}^3 \cdot 17,5\text{m} \\ &= 10500 \text{ Kg/m} \\ \text{Berat aspal} &= 0,07\text{m} \cdot 17,5\text{m} \cdot 2200 \text{ Kg/m} \\ &= 2695 \text{ Kg/m}\end{aligned}$$

Live Load (LL)

Beban Terbagi Rata (BTR)

$$\text{BTR} = 9 \text{ kN/m}^2 \quad \dots \text{SNI 1725-2016 Pasal 8.3.1}$$

$$\begin{aligned}\text{W}_{\text{LL1}} &= \text{BTR} \cdot \lambda \cdot \text{Lebar jembatan} \cdot \text{FB} \\ &= 900\text{Kg/m}^2 \cdot 17,5\text{m} \cdot 2 \\ &= 31500 \text{ Kg}\end{aligned}$$

Beban Garis (BGT)

$$\text{BGT} = 4900 \text{ Kg/m} \quad \dots \text{SNI 1725-2016 Pasal 6.3.1}$$

$$\begin{aligned}\text{W}_{\text{LL2}} &= \text{BGT} \cdot \text{Lebar jembatan} \cdot \text{FB} \\ &= 4900 \text{ Kg} \cdot 17,5\text{m} \cdot 2 \\ &= 171500 \text{ Kg}\end{aligned}$$

$$\begin{aligned}\text{W}_{\text{LL-TOTAL}} &= \text{W}_{\text{LL1}} + \text{W}_{\text{LL2}} \\ &= 31500 \text{ Kg} + 203000 \text{ Kg} \\ &= 203000 \text{ Kg}\end{aligned}$$

$$Asc = \frac{P_{ni}}{f_{ni}}$$

$$P_{ni} = \frac{(0,5 \cdot (\lambda_i + \lambda_{i+1}) \cdot W + p_{BGT})}{\sin \alpha_i}$$

$$W = DL + q_{BTR}$$

$$f_{ni} = f_{ijin} - \gamma_{cb} \cdot \frac{a_1}{\cos \alpha_i}$$

Asc	= luas penampang kabel (mm^2)
P_{ni}	= beban yang bekerja pada dek (kN)
f_{ni}	= tegangan ijin kabel netto (kN/m^2)
f_{ijin}	= tegangan ijin kabel (MPa)
λ_i	= jarak antar kabel i (m)
a_1	= jarak dari pylon ke kabel ke i (m)
α_i	= sudut kemiringan kabel terhadap bidang horizontal
γ_{cb}	= densitas kabel (77 kN/m^3)

Berdasarkan spesifikasi kabel yang telah diberikan, dipilih tipe ASTM 416-06 Grade 270 yang disuplai oleh VSL SSI 2000, dengan tegangan ijin kabel sebagai berikut:

$$\begin{aligned} f_{ijin} &= 0,45 \cdot 1860 \text{ MPa} \\ &= 837 \text{ MPa} \\ &= 83700 \text{ Kg/m}^2 \end{aligned}$$

Perhitungan luasan kabel yang dibutuhkan dapat dilihat pada Tabel 4.2.

Tabel 4. 2 Perhitungan jumlah strand dalam setiap susunan kabel

no	derajat α	$\sin \alpha$	$\cos \alpha$	λ	$\lambda+1$
1	31	0.515	0.857	8	8
2	34	0.559	0.829	8	8
3	36	0.588	0.809	8	8
4	40	0.643	0.766	8	8
5	44	0.695	0.719	8	8
6	51	0.777	0.629	8	8
7	60	0.866	0.500	8	8
8	73	0.956	0.292	8	8
no	W (Kg)	Pni (kN)	fni (MPa)	Asc (mm ²)	n
1	47335.0	33991.27	747	4549	32
2	47335.0	31307.26	744	4207	30
3	47335.0	29784.35	742	4015	29
4	47335.0	27235.75	736	3698	26
5	47335.0	25202.03	730	3453	25
6	47335.0	22527.04	715	3152	23
7	47335.0	20215.11	683	2960	21
8	47335.0	18306.72	574	3191	23

Berdasarkan analisa di atas, maka ditentukan jumlah strand dalam masing-masing kabel adalah sebanyak 37 buah

4.1.5 Struktur Pylon

Besarnya dimensi *pylon* diperkirakan berdasar nilai jumlah gaya aksial tekan kabel untuk satu sisi kolom vertikal.

- 1) Material *pylon* = beton bertulang
- 2) f'_c = 40 Mpa
- 3) f_y = 420 Mpa

Besarnya gaya yang terjadi pada *pylon* akibat kabel dapat dilihat pada tabel 4.3.

Tabel 4. 3 Rekapitulasi gaya yang bekerja pada pylon

no	derajat α	WDL (Kg)	WLL (Kg)	(WDL+WLL) x $\sin\alpha$ (Kg)
1	31	277112.5	203000	247276.2177
2	34	277112.5	203000	268475.5029
3	36	277112.5	203000	282203.0469
4	40	277112.5	203000	308610.3663
5	44	277112.5	203000	333514.1669
			TOTAL	1440079.301

Dimensi *pylon* :

$$\begin{aligned}
 A &= \frac{2 \cdot N_{gi}}{f'_c} \\
 &= \frac{2 \cdot 144007930 \text{ N}}{0,04 \text{ N/mm}^2} \\
 &= 720039,7 \text{ mm}^2 \\
 &= 7200,397 \text{ cm}^2
 \end{aligned}$$

Luas Penampang direncanakan :

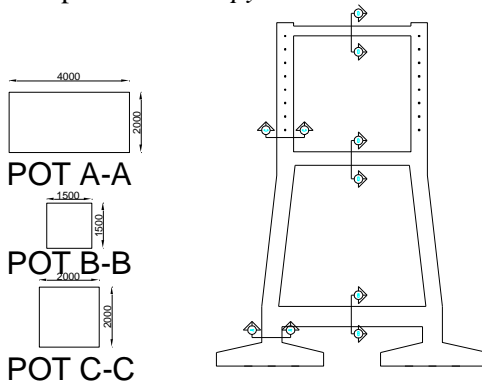
$$A = b \cdot (2 \cdot b)$$

$$= 2 \cdot b^2$$

$$b = 85 \text{ cm}$$

$$h = 170 \text{ cm}$$

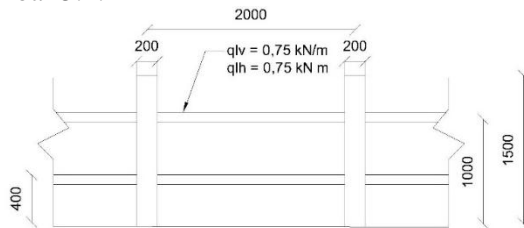
Jadi dipakai dimensi *pylon* $b = 200 \text{ cm}$ dan $h = 400 \text{ cm}$

Gambar 4. 4 Hasil *preliminary* pylon

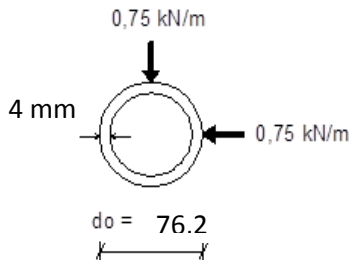
4.2 Perencanaan Sekunder

4.2.1 Perencanaan Pipa Sandaran

Berdasarkan pada RSNI T-02-2005 pasal 12.5, beban yang bekerja pada sandaran adalah berupa gaya horizontal dan vertikal sebesar $w = 0,75 \text{ kN/m}$. Sandaran menggunakan profil pipa dengan diameter 60,5 mm, lihat Gambar 5.1.



Gambar 4. 5 Beban yang bekerja pada pipa sandaran



Gambar 4. 6 Profil pipa sandaran

Analisa pembebanan

1. Beban Vertikal

Berat sandaran pejalan kaki	= 0,75	kN/m
Berat pipa sandaran Ø3"	= 0,071	kN/m
Berat total	= 0,821	kN/m

$$\begin{aligned}
 \text{Momen vertikal} &= 1/8 \times q \times \text{panjang pipa}^2 \\
 &= 1/8 \times 0,821 \times (2\text{m})^2 \\
 &= 0,411 \text{ kNm}
 \end{aligned}$$

2. Beban Horizontal

$$\begin{aligned}\text{Beban sandaran} &= \text{Berat sandaran pejalan kaki} \\ &= 0,75 \text{ kNm}\end{aligned}$$

$$\begin{aligned}\text{Momen horizontal} &= 1/8 \times q \times \text{panjang pipa}^2 \\ &= 1/8 \times 0,75 \times (2\text{m})^2 \\ &= 0,375 \text{ kNm}\end{aligned}$$

Setelah didapat beban vertikal dan horizontal maka dilakukan kontrol kekuatan pipa.

$$\begin{aligned}M_n &= 0,9 \times f_y \times \text{momen inersia pipa} \\ &= 0,9 \times 240 \text{ MPa} \times 15600 \text{ mm}^2 \\ &= 3369600 \text{ Nmm} \\ &= 3,37 \text{ kNm}\end{aligned}$$

$$\begin{aligned}M_r &= \sqrt{M_{\text{vertikal}}^2 + M_{\text{horizontal}}^2} \\ &= \sqrt{0,411^2 + 0,375^2} \\ &= 0,556 \text{ kNm}\end{aligned}$$

Kontrol kekuatan pipa

$$\begin{aligned}M_r/M_n &< 1 \\ 0,556/3,37 &< 1 \\ 0,165 &< 1 \quad (\text{OK})\end{aligned}$$

Lendutan yang terjadi pada pipa

$$\begin{aligned}\text{Lendutan ijin } (\delta_{\text{ijin}}) &= L/240 \\ &= 200/240 \\ &= 0,833 \text{ cm}\end{aligned}$$

Lendutan yang terjadi akibat gaya vertikal

$$\begin{aligned}\delta_v &= \frac{5 \times q_{\text{vertikal}} \times L^4}{384 \times E \times I_x} \\ &= \frac{5 \times 0,821 \times 2^4}{384 \times 21000000000 \times 59,5 \times 10^8} \\ &= 0,0014 \text{ cm}\end{aligned}$$

Lendutan yang terjadi akibat gaya horizontal

$$\begin{aligned}\delta_v &= \frac{5 \times q_{\text{horizontal}} \times L^4}{384 \times E \times I_x} \\ &= \frac{5 \times 0,75 \times 2^4}{384 \times 21000000000 \times 59,5 \times 10^8} \\ &= 0,0013 \text{ cm}\end{aligned}$$

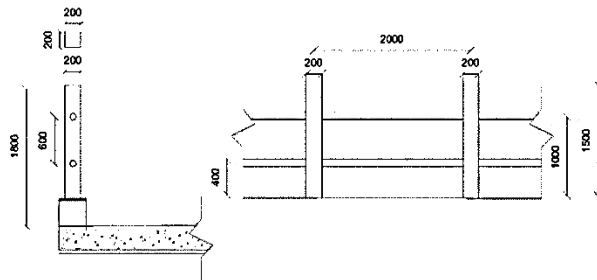
Lendutan resultan

$$\begin{aligned}\delta r &= \sqrt{\delta v^2 + \delta h^2} \\ &= \sqrt{0,0014^2 + 0,0013^2} \\ &= 0,002 \text{ cm}\end{aligned}$$

Kontrol lendutan

$$\begin{aligned}\delta r &< \delta_{ijin} \\ 0,002 \text{ cm} &< 0,833 \text{ cm (OK)}\end{aligned}$$

4.2.2 Perencanaan Tiang Sandaran



Gambar 4. 7 Detail tiang sandaran

a. Analisa pembebanan

1. Beban mati

$$\begin{aligned}\text{Berat sendiri tiang} &= b \times h \times L \times \gamma_{\text{beton}} \\ &= 0,2 \times 0,2 \times 1,5 \times 24 \\ &= 1,44 \text{ kN}\end{aligned}$$

$$\begin{aligned}\text{Berat pipa sandaran} &= \text{berat pipa} \times n \times L_{\text{pipa}} \\ &= 0,0713 \times 2 \times 2 \\ &= 0,285 \text{ kN}\end{aligned}$$

$$\begin{aligned}\text{Berat total (PDL)} &= \text{berat sendiri tiang} + \text{berat pipa} \\ &= 1,44 \text{ kN} + 0,285 \text{ kN} \\ &= 1,725 \text{ kN}\end{aligned}$$

$$\begin{aligned}\text{MDL} &= \text{PDL} \times b/2 \\ &= 1,725 \times (0,2 \text{ m} / 2) \\ &= 0,173 \text{ kNm}\end{aligned}$$

2. Beban hidup

Beban pejalan kaki (q_L) = 0,75 kN/m

$$\begin{aligned}\text{Berat pejalan kaki (PLL)} &= q_L \times L \\ &= 0,75 \text{ kN/m} \times 2 \text{ m} \\ &= 1,5 \text{ kN}\end{aligned}$$

$$\begin{aligned}\text{MLL} &= \text{PLL} \times h \\ &= 1,5 \text{ kN} \times 1,5 \text{ m} \\ &= 2,25 \text{ kNm}\end{aligned}$$

$$\begin{aligned}\text{Pu} &= (1,2 \times \text{PDL}) + (1,6 \times \text{PLL}) \\ &= (1,2 \times 1,725) + (1,6 \times 1,5) \\ &= 4,47 \text{ kN}\end{aligned}$$

$$\begin{aligned}\text{Mu} &= (1,2 \times \text{MDL}) + (1,6 \times \text{MLL}) \\ &= (1,2 \times 0,173) + (1,6 \times 2,25) \\ &= 3,807 \text{ kNm}\end{aligned}$$

b. Penulangan tiang sandaran

1. Penulangan lentur

$$\begin{aligned}m &= \frac{f_y}{0,85 \times f_{c'} \times \frac{240}{240}} \\ &= \frac{f_y}{0,85 \times 30} \\ &= 9,41\end{aligned}$$

$$\begin{aligned}\text{Mn} &= \frac{\text{Mu}}{\phi} \\ &= \frac{3807024}{0,8} \\ &= 4758780 \text{ Nmm}\end{aligned}$$

$$\begin{aligned}\text{Rn} &= \frac{\text{Mn}}{b \times d^2} \\ &= \frac{4758780}{200 \times 200^2} \\ &= 0,595 \text{ N/mm}^2\end{aligned}$$

$$\begin{aligned}\rho \text{ balance} &= \frac{0,85 \times \beta_1 \times f_{c'}}{f_y} \times \left(\frac{600}{600 + f_y} \right) \\ &= \frac{0,85 \times 0,85 \times 30}{240} \times \left(\frac{600}{600 + 240} \right) \\ &= 0,065\end{aligned}$$

$$\begin{aligned}
 \rho_{\min} &= \frac{1,4}{f_y} \\
 &= \frac{1,4}{240} \\
 &= 0,006 \\
 \rho_{\max} &= 75\% \times \rho_{\text{balance}} \\
 &= 75\% \times 0,065 \\
 &= 0,048 \\
 \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\
 &= \frac{1}{9,41} \left(1 - \sqrt{1 - \frac{2 \times 9,41 \times 0,595}{240}} \right) \\
 &= 0,003
 \end{aligned}$$

Kontrol, $\rho_{\min} > \rho_{\text{perlu}} > \rho_{\max}$

Karena dari kontrol yang didapat $\rho_{\text{perlu}} < \rho_{\min}$ maka digunakan $\rho_{\min} = 0,006$

$$\begin{aligned}
 d &= h - d' - \emptyset \text{ tul. lentur} - (0,5 \times \emptyset \text{ tul. bagi}) \\
 &= 200 - 30 - 12 - (0,5 \times 10) \\
 &= 153 \text{ mm} \\
 &= 0,153 \text{ m}
 \end{aligned}$$

$$\begin{aligned}
 A_s &= \rho \times b \times d \\
 &= 0,006 \times 200 \times 153 \\
 &= 178,5 \text{ mm}^2
 \end{aligned}$$

Maka untuk tulangan lentur digunakan **4 Ø12**
($A_s = 452,389 \text{ mm}^2$)

2. Penulangan geser

$$V_u = P_u = 4,47 \text{ kN} = 4470,24 \text{ N}$$

$$\begin{aligned}
 V_c &= \left(\frac{\sqrt{f_{c'}}}{6} \right) \times b_w \times d \\
 &= \left(\frac{\sqrt{30}}{6} \right) \times 200 \times 153 \\
 &= 27933,9 \text{ N}
 \end{aligned}$$

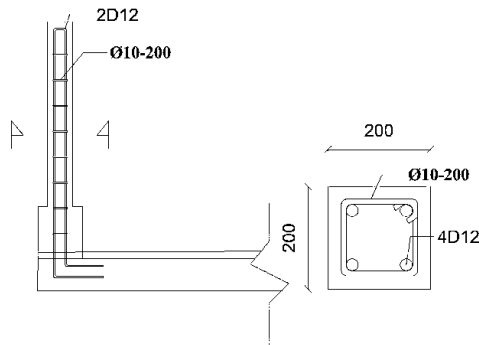
$$\begin{aligned}
 \emptyset V_c &= 0,75 \times V_c \\
 &= 0,75 \times 27933,9 \text{ N} = 20950,4 \text{ N}
 \end{aligned}$$

Kontrol, $V_u \leq \emptyset V_c$, dari kontrol yang didapat $V_u = 4470,24 \text{ N} < \emptyset V_c = 20950,4 \text{ N}$, maka tidak perlu

tulangan geser. Walaupun tidak menggunakan tulangan geser tapi untuk menjaga kestabilan struktur maka dipasang tulangan geser minimum dengan jarak maksimal.

$$\begin{aligned}
 S &= \frac{A_v \times f_y}{\frac{1}{3} \times b \times \sqrt{f_y}} \\
 &= \frac{157,08 \times 240}{\frac{1}{3} \times 200 \times \sqrt{30}} \\
 &= 103,24 \text{ mm}
 \end{aligned}$$

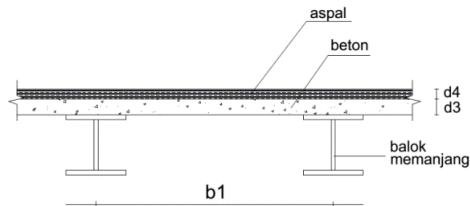
Maka untuk menjaga kestabilan struktur dipasang tulangan geser **Ø2 - 200** ($A_s = 62831,9 \text{ mm}^2$)



Gambar 4. 8 Detail penulangan tiang sandaran

4.2.3 Perencanaan Pelat Lantai Kendaraan

Perencanaan plat lantai yang berfungsi sebagai jalan kendaraan pada jembatan harus mempunyai tebal minimum t_s , yang memenuhi ketentuan dalam **RSNI T-12-2004**.



Gambar 4. 9 Lantai kendaraan

$$\begin{aligned}
 \text{Dimensi pelat} &= t_s \geq 200 \text{ mm} \\
 &= t_s \geq 100 + 40 \text{ b1 mm} \\
 &= t_s \geq 100 + 40 (1,75 \text{ m}) \text{ mm} \\
 &= t_s \geq 170 \text{ mm}
 \end{aligned}$$

Jadi dipakai tebal pelat lantai = 250 mm

4.2.3.1 Pembebanan

a. Beban Mati (MS)

$$\begin{aligned}
 \text{Lantai jembatan} &= t_s \times \gamma_{\text{beton}} \times b \\
 &= 0,25 \text{ m} \times 24 \text{ kN/m}^3 \times 1 \text{ m} \\
 &= 6 \text{ kN/m}
 \end{aligned}$$

$$Q_{\text{MS}} = 6 \text{ kN/m}$$

b. Beban Mati Tambahan (MA)

$$\begin{aligned}
 \text{Aspal} &= t_{\text{aspal}} \times \gamma_{\text{Aspal}} \times b \\
 &= 0,07 \text{ m} \times 22 \text{ kN/m}^3 \times 1 \text{ m} \\
 &= 1,54 \text{ kN/m}
 \end{aligned}$$

$$\begin{aligned}
 \text{Air hujan} &= t_{\text{air hujan}} \times \gamma_{\text{Air}} \times b \\
 &= 0,05 \text{ m} \times 9,8 \text{ kN/m}^3 \times 1 \text{ m} \\
 &= 0,49 \text{ kN/m}
 \end{aligned}$$

$$\begin{aligned}
 Q_{\text{MA}} &= Q_{\text{MA} 1} + Q_{\text{MA} 2} \\
 &= 1,54 \text{ kN/m} + 0,49 \text{ kN/m} \\
 &= 2,03 \text{ kN/m}
 \end{aligned}$$

c. Beban Hidup

- Beban Truk

Faktor beban dinamis, DLA = 30%

Beban truk, T = 112,5 kN

$$\begin{aligned}
 P_{\text{TT}} &= T \times \text{KD} \\
 &= T \times (1 + \text{DLA})
 \end{aligned}$$

$$= 112,5 \text{ kN} \times (1 + 0,3)$$

$$= 146,25 \text{ kN}$$

- Beban Angin

Tabel 4. 4 Nilai V_0 dan Z_0

Kondisi	Lahan Terbuka	Sub Urban	Kota
V_0 (km/jam)	13,2	17,6	19,3
Z_0 (mm)	70	1000	2500

$$V_{dz} = 2,5 v_0 \left(\frac{v_{10}}{v_B} \right) \ln \frac{Z}{Z_0}$$

$$= 2,5 \cdot 13,2 \left(\frac{100}{100} \right) \ln \frac{1100}{70}$$

$$= 167 \text{ km/jam}$$

$$= 46,36 \text{ m/s}$$

Tabel 4. 5 Tekanan angin dasar

Komponen Bangunan Atas	Angin tekan (MPa)	Angin hisap (MPa)
Rangka, Kolom, dan Pelengkung	0,0024	0,0012
Balok	0,0024	N/A
Permukaan datar	0,0019	N/A

Tekanan angin yang digunakan adalah 0,0019 MPa

$$PD = Pb \left(\frac{v_{dz}}{v_B} \right)^2$$

$$= 0,0019 \left(\frac{166,89}{100} \right)^2$$

$$= 0,00245 \text{ MPa}$$

$$= 245 \text{ Kg/m}^2$$

Beban angin yang diterima pelat adalah

$$PD = PD \times t_{\text{pelat}} \times 1 \text{ m}$$

$$= 245 \text{ Kg/m}^2 \times 0,25 \text{ m} \times 1 \text{ m}$$

$$= 61,36 \text{ Kg}$$

$$= 0,614 \text{ kN}$$

- Pengaruh Temperatur

$$\text{Faktor beban layan} = 1$$

$$\text{Faktor beban ultimit} = 1,2$$

Temperatur rata-rata minimum	= 15°C
Temperatur rata-rata maksimum	= 40°C
Selisih temperatur	= (40-15)°C
	= 25 °C
Kuat tekan beton	= 40 Mpa
Modulus elastisitas (E)	= 29725 MPa
Koefisien akibat temperatur (α)	= 0,00001
Momen Inersia lantai beton	
I	= $1/12 \times b \times h^3$
	= $1/12 \times 1000 \text{ mm} \times (250 \text{ mm})^3$
	= 1302083333 mm ⁴

4.2.3.2 Perhitungan Momen

- a. Akibat Beban Mati (Q_{MS})
 - Momen tumpuan max

$$= 1/12 \times Q_{MS} \times S^2$$

$$= 1/12 \times 6 \text{ kN/m} \times (1,75 \text{ m})^2$$

$$= 1,595 \text{ kNm}$$
 - Momen lapangan max

$$= 1/24 \times Q_{MS} \times S^2$$

$$= 1/24 \times 6 \text{ kN/m} \times (1,75 \text{ m})^2$$

$$= 0,798 \text{ kNm}$$
- b. Akibat Beban Mati Tambahan (Q_{MA})
 - Momen tumpuan max

$$= 5/48 \times Q_{MA} \times S^2$$

$$= 5/48 \times 2,03 \text{ kN/m} \times (1,75 \text{ m})^2$$

$$= 0,65 \text{ kNm}$$
 - Momen lapangan max

$$= 5/96 \times Q_{MA} \times S^2$$

$$= 5/96 \times 2,03 \text{ kN/m} \times (1,75 \text{ m})^2$$

$$= 0,32 \text{ kNm}$$

c. Akibat Beban Hidup

- Akibat Beban Truk (P_{TT})

Momen tumpuan max

$$\begin{aligned}
 &= 5/32 \times P_{TT} \times S \\
 &= 5/32 \times 146,3 \text{ kN/m} \times 1,75 \text{ m} \\
 &= 39,99 \text{ kNm}
 \end{aligned}$$

Momen lapangan max

$$\begin{aligned}
 &= 9/64 \times P_{TT} \times S \\
 &= 9/64 \times 146,3 \text{ kN/m} \times 1,75 \text{ m} \\
 &= 35,99 \text{ kNm}
 \end{aligned}$$

- Akibat Beban Angin (P_{ew})

Kondisi Layan

Momen Tumpuan max

$$\begin{aligned}
 &= 5/32 \times P_{ew} \times S \\
 &= 5/32 \times 0,614 \text{ kN} \times 1,75 \text{ m} \\
 &= 0,17 \text{ kNm}
 \end{aligned}$$

Momen Lapangan max

$$\begin{aligned}
 &= 9/64 \times P_{ew} \times S \\
 &= 9/64 \times 0,6 \text{ kN} \times 1,75 \text{ m} \\
 &= 0,15 \text{ kNm}
 \end{aligned}$$

Kondisi Ultimit

Momen Tumpuan max

$$\begin{aligned}
 &= 5/32 \times P_{ew} \times S \\
 &= 5/32 \times 0,514 \text{ kN} \times 1,75 \text{ m} \\
 &= 0,17 \text{ kNm}
 \end{aligned}$$

Momen Lapangan max

$$\begin{aligned}
 &= 9/64 \times P_{ew} \times S \\
 &= 9/64 \times 0,514 \text{ kN} \times 1,75 \text{ m} \\
 &= 0,15 \text{ kNm}
 \end{aligned}$$

- Akibat Pengaruh Temperatur (T)

Momen Tumpuan max

$$= 1/4 \times \Delta T \times \alpha \times EI/h$$

$$= 1/4 \times 25^\circ\text{C} \times 0,00001 \times (1,5 \times 10^{13}/200\text{mm})$$

$$= 9,7 \text{ kNm}$$

Momen Lapangan max

$$= 7/8 \times \Delta T \times \alpha \times EI/h$$

$$= 7/8 \times 25^\circ\text{C} \times 0,00001 \times (1,55 \times 10^{13}/200\text{mm})$$

$$= 33,87 \text{ kNm}$$

4.2.3.3 Kombinasi Beban Pada Pelat Lantai

Tabel 4. 6 Rekapitulasi momen lapangan dan tumpuan

No	Jenis beban	Faktor Layan	Keadaan Ultimate	M Lap(kNm)	M tump (kNm)
1	B. Mati	1	1.3	0.798	1.595
2	B. Mati Tambahan	1	2	0.32	0.65
3	Beban Truk	1	1.8	35.99	39.99
4	Pengaruh temperatur	1	1.2	33.87	9.68
5a	Beban angin	1		0.15	0.17
5b	Beban angin		1.2	0.15	0.17

Tabel 4. 7 Kombinasi 1 Momen Lapangan Pada Pelat

No	Jenis beban	Faktor Beban		M Lap(kNm)	Layan	Ultimit
		Layan	Ultimate		Ms Lap	Mu Lap
1	B. Mati	1	1.3	0.798	0.798	1.037
2	B. Mati Tambahan	1	2	0.32	0.324	0.648
3	Beban Truk	1	1.8	35.99	35.991	64.784
4	Peng. temperatur	1	1.2	33.87	33.867	33.867
5a	Beban angin	1		0.15		
5b	Beban angin		1.2	0.15		
				Σ	70.979	100.335

Tabel 4. 8 Tabel 5. 5 Kombinasi 2 Momen Lapangan Pada Pelat

No	Jenis beban	Faktor Beban		M Lap(kNm)	Layan	Ultimit
		Layan	Ultimate		Ms Lap	Mu Lap
1	B. Mati	1	1.3	0.798	0.798	1.037
2	B. Mati Tambahan	1	2	0.32	0.324	0.648
3	Beban Truk	1	1.8	35.99	35.991	35.991
4	Peng. temperatur	1	1.2	33.87	23.707	
5a	Beban angin	1		0.15		
5b	Beban angin		1.2	0.15		
				Σ	60.819	37.676

Tabel 4. 9 Kombinasi 1 Momen Tumpuan Pada Pelat

No	Jenis beban	Faktor Beban		M Tump(kNm)	Layan	Ultimit
		Layan	Ultimate		Ms Tum	Mu Tum
1	B. Mati	1	1.3	1.595	1.595	2.074
2	B. Mati Tambahan	1	2	0.65	0.648	1.295
3	Beban Truk	1	1.8	39.99	39.990	71.982
4	Pengaruh temperatur	1	1.2	9.68	9.68	9.68
5a	Beban angin	1		0.17		
5b	Beban angin		1.2	0.17		
				Σ	51.909	85.027

Tabel 4. 10 Kombinasi 2 Momen Tumpuan Pada Pelat

No	Jenis beban	Faktor Beban		M Tump(kNm)	Layan	Ultimit
		Layan	Ultimate		Mu Tum	Mu Tum
1	B. Mati	1	1.3	1.595	1.595	2.074
2	B. Mati Tambahan	1	2	0.65	0.648	1.295
3	Beban Truk	1	1.8	39.99	39.990	39.990
4	Pengaruh temperatur	1	1.2	9.68	6.773	
5a	Beban angin	1		0.17		
5b	Beban angin		1.2	0.17		
				Σ	49.006	43.359

4.2.3.4 Penulangan Pelat Lantai

- Tulangan Lapangan

- Data:

Momen rencana = 1000,3 kNm

Mutu beton f_c' = 40 MPa

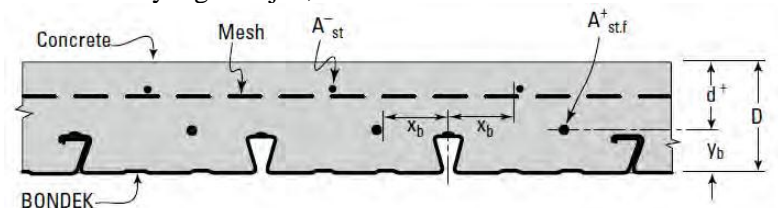
Mutu baja f_y = 550 MPa

Tebal plat lantai rencana (T_p) = 250 mm

y_b = 51 mm

Tebal efektif (d) = $h - y_b - (1/2D)$ = 182 mm

Lebar lantai yang ditinjau, b = 1000 mm



- Penulangan lentur

$$\begin{aligned}
 m &= \frac{f_y}{0,85 \times f_{c'}} \\
 &= \frac{550}{0,85 \times 40} \\
 &= 16,18 \\
 M_n &= \frac{M_u}{\phi} \\
 &= \frac{100335395}{0,8} \\
 &= 125419244 \text{ Nmm}
 \end{aligned}$$

$$\begin{aligned}
 R_n &= \frac{M_n}{b \times d^2} \\
 &= \frac{125419244}{1000 \times 191^2} \\
 &= 3,44 \text{ N/mm}^2
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{balance}} &= \frac{0,85 \times \beta_1 \times f_{c'}}{f_y} \times \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 0,85 \times 40}{550} \times \left(\frac{600}{600 + 550} \right) \\
 &= 0,027
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{min}} &= \frac{1,4}{f_y} \\
 &= \frac{1,4}{550} \\
 &= 0,0025
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{max}} &= 75\% \times \rho_{\text{balance}} \\
 &= 75\% \times 0,027 \\
 &= 0,0206
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\
 &= \frac{1}{16,18} \left(1 - \sqrt{1 - \frac{2 \times 16,18 \times 3,4}{550}} \right) \\
 &= 0,0066
 \end{aligned}$$

Kontrol, $\rho_{\text{min}} > \rho_{\text{perlu}} > \rho_{\text{max}}$

Karena dari kontrol yang didapat $\rho_{\text{perlu}} > \rho_{\text{min}}$ maka digunakan $\rho_{\text{perlu}} = 0,0066$

$$\begin{aligned}
 A_s &= \rho \times b \times d \\
 &= 0,0066 \times 1000 \times 191 \\
 &= 1261 \text{ mm}^2
 \end{aligned}$$

Maka untuk tulangan lentur digunakan **Bondek dengan ketebalan 0,9 mm**

$$\begin{aligned}
 A_s \text{ aktual} &= A_s \text{ bondek} \\
 &= 1503 \text{ mm}^2
 \end{aligned}$$

• Tulangan Tumpuan

- Data:

$$\begin{aligned}
 \text{Momen rencana} &= 85,02 \text{ kNm} \\
 \text{Mutu beton } f_c' &= 40 \text{ MPa} \\
 \text{Mutu baja } f_y &= 390 \text{ MPa} \\
 \text{Tebal plat lantai rencana (Tp)} &= 250 \text{ mm} \\
 \text{Decking beton (d')} &= 40 \text{ mm} \\
 \text{Tebal efektif (d) = h - d-(1/2D)} &= 202 \text{ mm} \\
 \text{Lebar lantai yang ditinjau, b} &= 1000 \text{ mm} \\
 \text{Diameter tul. rencana} &= 16 \text{ mm}
 \end{aligned}$$

- Penulangan lentur

$$\begin{aligned}
 m &= \frac{f_y}{0,85 \times f_c'} \\
 &= \frac{390}{0,85 \times 40} \\
 &= 11,47 \\
 M_n &= \frac{M_u}{\phi} \\
 &= \frac{85027412}{0,8} \\
 &= 106284265 \text{ Nmm}
 \end{aligned}$$

$$\begin{aligned}
 R_n &= \frac{M_n}{b \times d^2} \\
 &= \frac{106284265}{1000 \times 202^2} \\
 &= 2,6 \text{ N/mm}^2
 \end{aligned}$$

$$\begin{aligned}
 \rho \text{ balance} &= \frac{0,85 \times \beta_1 \times f_c'}{f_y} \times \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 0,85 \times 40}{390} \times \left(\frac{600}{600 + 390} \right) \\
 &= 0,045
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\min} &= \frac{1,4}{f_y} \\
 &= \frac{1,4}{390} \\
 &= 0,0036 \\
 \rho_{\max} &= 75\% \times \rho_{\text{balance}} \\
 &= 75\% \times 0,044 \\
 &= 0,033 \\
 \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\
 &= \frac{1}{11,47} \left(1 - \sqrt{1 - \frac{2 \times 11,47 \times 2,6}{390}} \right) \\
 &= 0,0069
 \end{aligned}$$

Kontrol, $\rho_{\min} > \rho_{\text{perlu}} > \rho_{\max}$

Karena dari kontrol yang didapat $\rho_{\text{perlu}} > \rho_{\min}$ maka digunakan $\rho_{\text{perlu}} = 0,0069$

$$\begin{aligned}
 A_s &= \rho \times b \times d \\
 &= 0,0069 \times 1000 \times 202 \\
 &= 1405 \text{ mm}^2
 \end{aligned}$$

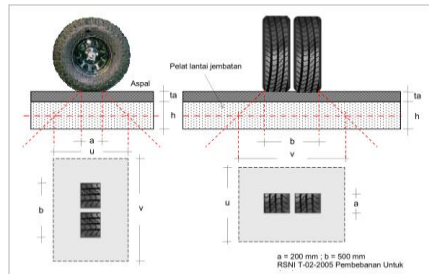
Maka untuk tulangan lentur digunakan **D16 - 120** ($A_s = 14675,52 \text{ mm}^2$)

- Penulangan bagi

$$\begin{aligned}
 A_s' &= 50\% \times A_s \text{ pasang} \\
 &= 50\% \times 1675,52 \text{ mm}^2 \\
 &= 837,75 \text{ mm}^2
 \end{aligned}$$

Direncanakan untuk tulangan bagi **D13 - 150** ($A_s' = 884,88 \text{ mm}^2$)

4.2.3.5 Geser Pons



Gambar 4. 10 Distribusi Geser Pons

Data:

Tebal aspal, t_a	= 70	mm
Tebal pelat, t_s	= 250	mm
Lebar roda, a	= 200	mm
Panjang roda, b	= 500	mm
Mutu beton, f_c'	= 30	MPa
Beban truk, P_{TT}	= 146,3	kN

Bidang geser pons

$$\begin{aligned} u &= a + 2 t_a + t_s \\ &= 200 + 140 + 250 \\ &= 590 \text{ mm} \end{aligned}$$

$$\begin{aligned} v &= b + 2 t_a + t_s \\ &= 500 + 140 + 250 \\ &= 890 \text{ mm} \end{aligned}$$

$$\begin{aligned} b' &= (2 \times u) + (2 \times v) \\ &= (2 \times 590) + (2 \times 890) \\ &= 2960 \text{ mm} \end{aligned}$$

Luas bidang geser pons (A_{pons})

$$\begin{aligned} A_{pons} &= b' \times d \\ &= 2960 \text{ mm} \times 250 \text{ mm} \\ &= 740000 \text{ mm}^2 \end{aligned}$$

Kekuatan nominal lantai terhadap geser tanpa tulangan geser,

$$\begin{aligned}
 V_c &= 1/6 \times \sqrt{f_c'} \times b' \times d \\
 &= 1/6 \times \sqrt{40} \times 2960 \times 250 \\
 &= 780 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 V_u &= \phi V_c \\
 &= 0,7 \times 780 \text{ kN} \\
 &= 546 \text{ kN}
 \end{aligned}$$

Kontrol

$$\begin{array}{ccc}
 V_u & > & P_{TT} \\
 546 \text{ kN} > & & 146,3 \text{ kN} \quad (\text{OK})
 \end{array}$$

BAB V

STRUKTUR UTAMA

Pada bab ini akan direncanakan gelagar memanjang dan melintang. Gelagar memanjang dan melintang di desain dan dihitung dengan mengacu pada RSNIT-03-2005 dan untuk pembebanan dan *load factor* mengikuti SNI 1725:2016

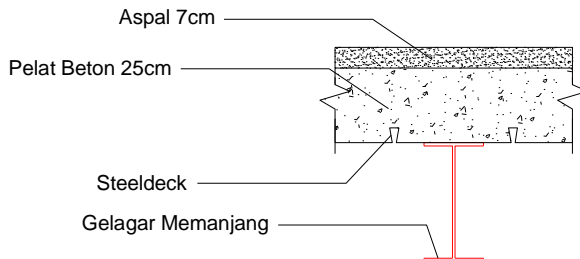
5.1 Gelagar Memanjang

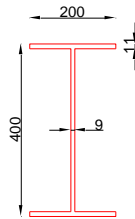
Dari hasil preliminary desain didapat data perencanaan profil untuk gelagar melintang H 400.200.9.12

d	= 400 mm	t _w	= 9 mm
b _f	= 200 mm	t _f	= 12 mm
A	= 82,63 cm ²	w	= 64,9 kg/m
I _x	= 22057,8 cm ⁴	i _x	= 16,3 cm
I _y	= 1602,28 cm ⁴	i _y	= 4,4 cm
S _x	= 1102,89 cm ³	Z _x	= 1249 cm ³
S _y	= 160,2 cm ³	Z _y	= 284 cm ³
E _s	= 200000 MPa		

sifat mekanis baja struktural

BJ	= 50
F _u	= 500 MPa
F _y	= 290 MPa





Gambar 5. 1 Potongan gelagar memanjang (mm)

5.1.1 Pembebanan

1) Data Awal

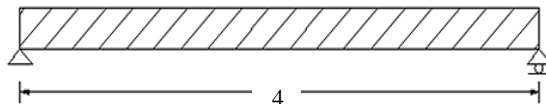
λ (panjang gelagar)	= 4 m
s(jarak antar gelagar)	= 1,75 m
t pelat beton	= 250 mm
t aspal	= 70 mm
γ beton	= 2500 Kg/m ³
γ aspal	= 2200 Kg/m ³
<i>Steeldeck</i>	= 8,954 Kg/m

2) Beban Mati

Aspal	= s. t aspal. γ aspal
	= 1,75 m. 70 mm/1000. 2200 Kg/m ³
	= 269,5 Kg/m
Pelat beton	= s. t pelat beton. γ beton
	= 1,75 m. 250 mm/1000. 2500 Kg/m ³
	= 1093,75 Kg/m

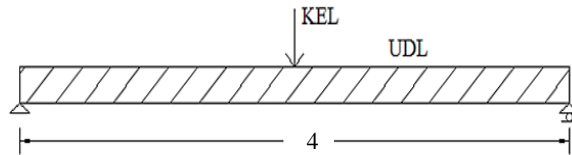
<i>Steeldeck</i>	= s. berat <i>steeldeck</i>
	= 1,75m. 8,954 Kg/m
	= 16 Kg/m

Berat Profil	= 65 Kg/m
--------------	-----------



Gambar 5. 2 Model perhitungan beban mati

3) Beban Hidup



Gambar 5. 3 Model perhitungan beban “D”

- BTR

BTR = Untuk $L > 30$ m

$$q = 9.0 (0.5 + 15/L) \text{ kPa}$$

$$q = 9.0 (0.5 + 15/144) \text{ kPa}$$

$$q = 544 \text{ Kg/m}^2$$

$$q_{\text{BTR}} = q \times s$$

$$= 5,44 \text{ kN/m}^2 \times 1,75 \text{ m}$$

$$= 952 \text{ Kg/m}$$

- BGT

DLA = 30 % untuk $L > 90$ m

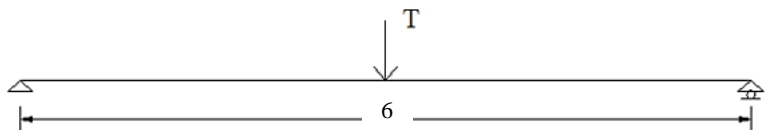
$$P_{\text{BGT}} = 4900 \text{ Kg/m}$$

$$P = P_{\text{BGT}} (1 + \text{DLA}) \times s$$

$$= 4900 \text{ Kg/m} (1 + 0,3) \times 1,75\text{m}$$

$$= 1147,5 \text{ Kg}$$

- Truk (T)



Gambar 5. 4 Model gambar perhitungan beban truk

$$\text{DLA} = 0,3$$

$$T = 112,5 \text{ kN (R-SNI T-02-2005)}$$

Menurut R-SNI T-02-2005 Pasal 6.4.1 tentang besarnya beban truk “T” di tentukan:

$$T_u = T \times (1 + \text{DLA})$$

$$= 11250 \text{ Kg} \times (1 + 0,3)$$

$$= 14625 \text{ Kg}$$

Tabel 5. 1 Rekapitulasi beban

JENIS BEBAN	NILAI	LF	TOTAL
BEBAN PELAT	1093.75	1.3	1422 Kg/m'
BEBAN ASPAL	269.5	1.3	350 Kg/m'
BEBAN STEELDECK	16	1.4	22 Kg/m'
BEBAN PROFIL	65	1.1	71 Kg/m'
BEBAN BTR	952	1.8	1713 Kg/m'
BEBAN BGT	11147.5	1.8	20066 Kg
BEBAN TRUK	14625	1.8	26325 Kg

5.1.2 Perhitungan Momen

a. Akibat beban mati

$$Q_{\text{Total}} = 1865,55 \text{ Kg/m}$$

$$M_{\text{DL}} = \frac{1}{8} \times Q_{\text{total}} \times \lambda^2 = \frac{1}{8} \times 1865,55 \text{ Kg/m} \times 4^2$$

$$= 3731,1 \text{ Kgm}$$

b. Akibat beban hidup

- Akibat BTR dan BGT

$$M_L = \frac{1}{8} \times q \times \lambda^2 + \frac{1}{4} \times P \times \lambda$$

$$= \frac{1}{8} \times 1713 \frac{\text{Kg}}{\text{m}} \times 4 + \frac{1}{4} \times 20066 \times 4$$

$$= 23491,125 \text{ Kgm}$$

- Akibat Truk

$$M_T = \frac{1}{4} \times P \times \lambda$$

$$= \frac{1}{4} \times 26325 \times 4$$

$$= 26325 \text{ Kgm}$$

Karena $M_L < M_T$, maka dipakai momen akibat beban Truk yaitu sebesar $M_T = 26325 \text{ Kgm}$

$$\text{Momen Total} = M_{\text{DL}} + M_T$$

$$= 3731,1 \text{ Kgm} + 26325 \text{ Kgm}$$

$$= 30056,1 \text{ Kgm}$$

5.1.3 Kontrol Kekuatan Gelagar Sebelum Komposit

- Tekuk lokal (RSNI T-03-2005 ps.7.2)

- Sayap

$$\lambda = \frac{bf}{2tf} = \frac{200}{2.16} = 6$$

$$\lambda_p = \frac{170}{\sqrt{fy}} = \frac{170}{\sqrt{410}} = 8$$

$$\lambda_r = \frac{370}{\sqrt{fy - fr}} = \frac{370}{\sqrt{410 - 70}} = 20$$

$$\lambda \leq \lambda_p \rightarrow \text{Penampang kompak}$$

- Badan

$$\lambda = \frac{h}{tw} = \frac{342}{12} = 38$$

$$\lambda_p = \frac{1680}{\sqrt{fy}} = \frac{1680}{\sqrt{410}} = 83$$

$$\lambda_r = \frac{2550}{\sqrt{fy}} = \frac{2550}{\sqrt{410}} = 126$$

$$\lambda \leq \lambda_p \rightarrow \text{Penampang kompak}$$

Karena $\lambda > \lambda_p$ (penampang kompak) maka kuat lentur nominal penampang adalah $M_n = M_p = Z_x f_y$

$$M_p = M_n = Z_x \times f_y$$

$$= 1249000 \times 410$$

$$= 512090000 \text{ Nmm} = 51209 \text{ Kgm}$$

$$M_u < \phi M_n$$

$$30056,1 \text{ Kgm} < 0,9 \times 51209 \text{ Kgm}$$

$$30056,1 \text{ Kgm} < 48357 \text{ Kgm (OK)}$$

- Tekuk lateral (RSNI T-03-2005 ps.7.3)

Dipasang shear connector praktis sejarak 100 cm sebagai pengaku arah lateral

$$L = 1000 \text{ mm}$$

$$L_p = 1,76 \times i_y \sqrt{\frac{E}{f_y}}$$

$$= 1,76 \times 4,4 \sqrt{\frac{200000}{410}} = 1710 \text{ mm}$$

$L \leq L_p \rightarrow$ Bentang pendek

$$\begin{aligned} M_p &= M_n = Z_x \times f_y = 1249000 \times 410 \\ &= 512090000 \text{ Nmm} = 51209 \text{ Kgm} \end{aligned}$$

Kapasitas momen :

$$\begin{aligned} \phi M_n &= 0,9 \times 51209 \text{ Kgm} \\ &= 48357 \text{ Kgm} > M_u = 30056,1 \text{ Kgm} \end{aligned}$$

5.1.4 Kontrol Lendutan

Menurut RSNI T-03-2005 ps.4.7.2 menyatakan lendutan maksimum gelagar diatas dua tumpuan adalah $L/800$.

$$\delta_{ijin} = 400/800 = 0,5 \text{ cm}$$

a. Lendutan akibat beban hidup (BTR + BGT)

$$\begin{aligned} \delta_{(udl + kel)} &= \frac{5}{384} \times \frac{q_L \lambda^4}{E I_x} + \frac{1}{48} \times \frac{P_1 \lambda^3}{E I_x} \\ &= \frac{5}{384} \times \frac{9,52 \times 400^4}{2000000 \times 22058} + \frac{1}{48} \times \frac{11147,5 \times 400^3}{200000 \times 22058} \\ &= 0,41 \text{ cm} \end{aligned}$$

b. Lendutan akibat beban tuk

$$\begin{aligned} \delta_{(T)} &= \frac{1}{48} \times \frac{P_T \lambda^3}{E I_x} \\ &= \frac{1}{48} \times \frac{14625 \times 400^3}{2000000 \times 22058} = 0,44 \text{ cm} \end{aligned}$$

Dipakai beban dari lendutan yang lebih besar yaitu akibat beban Truk = 0,44 cm

$$\delta_{(T)} \leq \delta_{ijin}$$

$$0,44 \leq 0,5 \text{ OK}$$

5.1.5 Kontrol Geser

Gaya geser maksimum terjadi apabila beban hidup berada dekat dengan perletakan.

a. Untuk beban hidup (BTR + BGT) :

$$\begin{aligned} V_{a \max} &= (P \times 1) + \left(Q_L \times \frac{1}{2} \times \lambda \right) \\ &= (20065,5 + 0,5 \cdot 1712,81 \cdot 4) \\ &= 23491,13 \text{ Kg} \end{aligned}$$

b. Untuk beban T :

$$\begin{aligned} V_{a \max} &= T \times (1 + DLA) \times 1 \times LF \\ &= 112,5 \times (1 + 0,3) \times 1 \times 1,8 \\ &= 26325 \text{ Kg} \end{aligned}$$

c. Untuk beban Qd :

$$\begin{aligned} V_{a \max} &= \left(Q_d \times \frac{1}{2} \times \lambda \right) \\ &= 1865,55 \cdot 0,5 \cdot 4 \\ &= 3731,1 \text{ Kg} \end{aligned}$$

Jadi V_a yang digunakan adalah V_a akibat beban truk sebesar 26325 Kg. Maka kuat geser sebagai berikut (RSNI T-03-2005 ps.7.8) :

Luas penampang badan

$$\frac{h}{tw} = \frac{344}{9} = 38,2$$

$$K_n = 5 + \frac{5}{\left(\frac{a}{h}\right)^2} = 19,79$$

$$1,10 \sqrt{\frac{K_n E}{f_y}} = \sqrt{\frac{19,79 \cdot 200000}{410}} = 108,1$$

$$\frac{h}{tw} \leq 1,10 \sqrt{\frac{K_n \times E}{f_y}}, \text{ maka kuat geser :}$$

$$V_u \leq \phi V_n$$

$$\begin{aligned} \phi V_n &= \phi \times 0,6 \times f_y \times A_w \\ &= 0,9 \times 0,6 \times 4100 \times (40 \times 0,9) \\ &= 797,04 \text{ kN} \\ &= 79704 \text{ Kg} \geq 26325 \text{ Kg} \end{aligned}$$

5.1.6 Kontrol Kekuatan Lentur Sesudah Komposit

Menurut SNI T-03-2005 ps. 8.2.1 lebar efektif pelat beton diambil nilai terkecil dari:

- 1/5 bentang gelagar
- Jarak antar gelagar

Dimana:

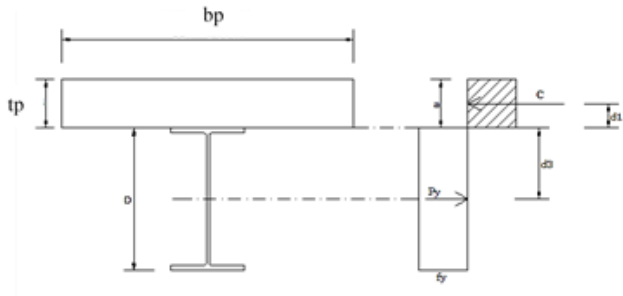
$L = 4000$ mm (panjang bentang)

$\lambda = 1,75$ m (jarak antar gelagar memanjang)

$b_{eff} < L/5 = 4000/5 = 800$ mm

$b_{eff} < s = 1750$ mm

diambil yang terkecil, $b_{eff} = 800$ mm



Gambar 5. 5 Distribusi gaya pada penampang

Sumber: RSNI T-03-2005 Gambar 12

- Kontrol kriteria penampang :

$$\frac{h}{tw} = \frac{344}{9} = 38,2$$

$$\lambda_p = \frac{1680}{\sqrt{fy}} = \frac{1680}{\sqrt{410}} = 83$$

$$\frac{h}{tw} \leq \frac{1680}{\sqrt{fy}} \rightarrow \text{penampang kompak}$$

- Menentukan garis netral :

$$Ac = b_{eff} \times t_b = 800 \times 250 = 200000 \text{ mm}^2$$

$$C1 = As \times fy = 8263 \times 410 = 3387830 \text{ N}$$

$$C2 = 0.85 f'c \times Ac = 0.85 \times 40 \times 200000 = 6800000 \text{ N}$$

Sehingga nilai c diambil yang terkecil yaitu $C = 3387830$ N

$$a = \frac{c}{0,85 \cdot f_c' \cdot b_{eff}} = \frac{3387830}{0,85 \cdot 40 \cdot 800} = 124,72 \text{ mm}$$

karena $a \leq t$ maka sumbu netral berada pada plat beton.

- Kapasitas momen :

$$d_1 = t - a/2 = 250 - 124,72/2 = 187,72 \text{ mm}$$

$$d_2 = 0 \text{ mm (Profil baja tidak mengalami tekan)}$$

$$d_3 = d/2 = 400/2 = 200 \text{ mm}$$

$$p_y = A_s \times f_y = 8263 \times 410 = 3387830 \text{ N}$$

$$\begin{aligned} M_n &= C (d_1 + d_2) + p_y (d_3 - d_2) \\ &= 3387830 \text{ N} (187,72 + 0) + 3387830 \text{ N} (200 - 0) \\ &= 1313542027.41 \text{ Nmm} \end{aligned}$$

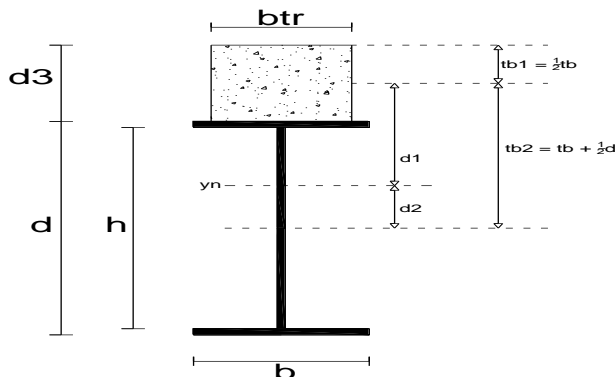
$$= 131354,202 \text{ Kgm}$$

$$\phi M_n = 0,90 \times 131354,202 \text{ Kgm}$$

$$= 118218.78 \text{ Kgm}$$

$$= 118218.78 \text{ Kgm} > M_u = 30056,1 \text{ Kgm} \rightarrow \text{OK}$$

Maka penampang telah memenuhi kekuatan lentur yang terjadi sesudah penampang komposit.



Gambar 5. 6 Gelagar komposit

Menghitung momen inersia penampang

- Menentukan nilai n

$$E_s = 200000 \text{ MPa}$$

$$E_c = 29725 \text{ MPa}$$

$$n = \frac{E_s}{E_c} = 6,73$$

- Luas konversi terhadap baja

$$b_{tr} = \frac{b_{eff}}{n} = \frac{80}{6,73} = 11,9 \text{ cm}$$

- Luas total (A_{tr})

$$A_{tr} = b_{tr} \times t_{pelat} = 11,9 \times 25 = 308,9 \text{ cm}^2$$

- $tb_1 = \frac{1}{2} \times t_{pelat}$

$$= \frac{1}{2} \times 250 = 125 \text{ mm}$$

- $tb_2 = t_{pelat} + (\frac{1}{2} \times d)$

$$= 250 + (\frac{1}{2} \times 400) = 450 \text{ mm}$$

- Mencari garis netral

Tabel 5. 2 Garis Netral Penampang Komposit

	A_n (mm)	Jarak serat atas ke titik berat benda (tb_1 , tb_2) (mm)	$A_n \times y_n$ (mm ²)
Beton	29725.41	125	3715676.251
Baja	8263	450	3718350
Jumlah	37988.4	-	7434026.251

$$- Y_n = \frac{\sum A_n \cdot Y_n}{\sum A_n} = \frac{7434026.251}{37988.4} = 195,7 \text{ mm}$$

- $d_1 = Y_n - (\frac{1}{2} \times t_{pelat})$

$$= 195,7 + (\frac{1}{2} \times 250) = 70,69 \text{ mm}$$

- $d_2 = tb_2 - Y_n$

$$= 450 - 195,7 = 254,3 \text{ mm}$$

- Momen inersia penampang

Tabel 5. 3 Momen Inersia Penampang

	An	d	Io	Io + A d ²
Beton	29725.41	70.69	1066666667	1215215022
Baja	8263	254.3	220578400	754967939.8

$$\begin{aligned}
 I_{\text{total}} &= 1215215022 \text{ mm}^4 + 754967939.8 \text{ mm}^4 \\
 &= 1970182962 \text{ mm}^4
 \end{aligned}$$

5.1.7 Perhitungan Shear Connector

Untuk jarak perhitungan shear connector (RSNI T-03-2005 (8.6)) tidak boleh melebihi nilai sebagai berikut:

- 600 mm
- 2 x tebal lantai
- 4 x tinggi shear connector

Untuk diameter shear connector tidak boleh melebihi :

- 1,5 x tebal plat flens bila plat memikul tegangan tarik
- 2 x tebal plat flens bila tidak terdapat tegangan tarik

Digunakan shear connector jenis paku / stud (ARCFIX *Stud Welding*) dengan data sebagai berikut:

- Diameter = 16 mm
- Tinggi = 150 mm
- $A_{sc} = 201,1 \text{ mm}^2$
- $f_c' = 40 \text{ MPa}$
- $E_c = 29725 \text{ MPa}$
- $F_u = 410 \text{ MPa}$

Kapasitas nominal 1 stud

$$\begin{aligned}
 Q_n &= 0,5 \times A_{sc} (f_c' \times E_c)^{0,5} \\
 &= 0,5 \times A_{sc} (f_c' \times E_c)^{0,5} \\
 &= 109621.0 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 V_{ls} &= 0,55 \times 2 \times 109621.0 \text{ N} \\
 &= 120583 \text{ N}
 \end{aligned}$$

Gaya geser yang bekerja:

$$V = 263250 \text{ N}$$

Gaya geser persatuan panjang :

$$V_L = \frac{V \times A_t \times Y_c}{I_t} = \frac{263250 \times 297,3,5 \times 7,1}{197018} = 2807,8 \text{ N}$$

$$V_L < \phi V_{ls}$$

$$2807,8 < 0,75 \times 120583$$

$$2807,8 < 90437,33 \text{ OK}$$

Jumlah shear connector :

$$V_h = A_s \times f_y = 8263 \text{ mm}^2 \times 410 \text{ MPa} = 3387830 \text{ N}$$

$$N = \frac{V_h}{Q_n} = \frac{3387830}{109621.0} = 31 \text{ buah}$$

Jadi jumlah shear connector yang dibutuhkan sepanjang gelagar memanjang adalah $2 \times n = 62$ buah

Jarak antar konektor yang digunakan

$$S = \frac{400}{31} = 13 \text{ cm}$$

Maka digunakan jumlah stud sebanyak 80 buah dengan 2 stud per gelombang steeldeck, sehingga ada 40 baris stud dengan jarak masing-masing baris stud adalah 100 mm.

5.1.8 Perhitungan Sambungan Gelagar Memanjang

a. Sambungan siku pada balok memanjang

- Gaya geser $v_u = 263,3 \text{ kN}$

- Rencana :

Dbaut = 2 cm

Dlubang = 2,2 cm

Tb baut = 145 kN

Pelat sambung (t) = 10 mm

Baut mutu tinggi gesek

Koef. Gesek (μ) = 0,35

Jumlah bidang geser (m) = 2

$\phi = 0,9$

kh = 1

$$\begin{aligned} V_n &= \mu \times m \times T_b \times k_h \\ &= 0,35 \cdot 2 \cdot 145 \cdot 1 \\ &= 101,5 \text{ kN} \end{aligned}$$

$$\begin{aligned} V_d &= \phi \times V_n \\ &= 0,9 \cdot 101,5 \\ &= 91,35 \text{ kN} \end{aligned}$$

$$\begin{aligned} n &= V_u / V_d \\ &= 263,3 / 91,35 \\ &= 2,9 \approx 4 \text{ buah} \end{aligned}$$

$$\begin{aligned} V_u &< n \cdot V_d \\ 263,3 &< 4 \cdot 91,35 \\ 263,3 &< 365,4 \text{ kN (OK)} \end{aligned}$$

- Syarat jarak baut (RSNI T-03-2005)

Jarak ke tepi (S_1) = 1,5db s/d (4tp+100) atau 200mm

$$1,5 \text{ db} = 1,5 \cdot 20 \text{ mm} = 30 \text{ mm}$$

$$4tp+100 = (4 \cdot 10 \text{ mm} + 100) = 140 \text{ mm}$$

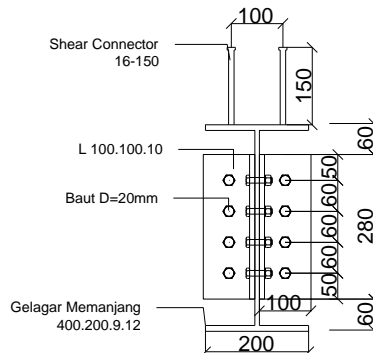
S_1 digunakan = 5cm

Jarak antar baut (S) = 2,5 db s/d 15tp atau 200mm

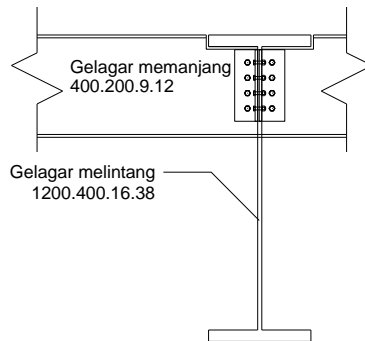
$$2,5 \text{ db} = 2,5 \cdot 20 \text{ mm} = 60 \text{ mm}$$

$$15tp = 15 \cdot 10 \text{ mm} = 150 \text{ mm}$$

S digunakan = 6cm



Gambar 5. 7 Detail sambungan gelagar memanjang (mm)



Gambar 5. 8 Detail sambungan gelagar memanjang ke melintang

5.2 Gelagar Melintang

Dari hasil preliminary desain didapat data perencanaan profil untuk gelagar melintang H 1200.400.16.38

d	$= 1200 \text{ mm}$	t_w	$= 16 \text{ mm}$
b_f	$= 400 \text{ mm}$	t_f	$= 38 \text{ mm}$
A	$= 486,34 \text{ cm}^2$	w	$= 381,8 \text{ kg/m}$
I_x	$= 1215889 \text{ cm}^4$	i_x	$= 50 \text{ cm}$
I_y	$= 40571,1 \text{ cm}^4$	i_y	$= 9,13 \text{ cm}$
S_x	$= 20264,82 \text{ cm}^3$	Z_x	$= 22716 \text{ cm}^3$
S_y	$= 2028,6 \text{ cm}^3$	Z_y	$= 3112 \text{ cm}^3$
E_s	$= 200000 \text{ MPa}$	h	$= 1060 \text{ mm}$

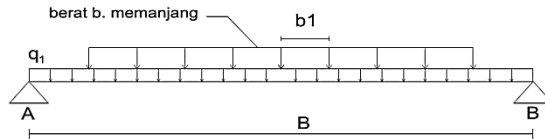
sifat mekanis baja struktural

BJ	$= 55$
F_u	$= 550 \text{ MPa}$
F_y	$= 410 \text{ MPa}$

5.2.1 Pembebanan

1) Data Awal	
λ (panjang gelagar)	$= 17,5 \text{ m}$
s (jarak antar gelagar)	$= 1,75 \text{ m}$
t pelat beton	$= 250 \text{ mm}$
t aspal	$= 70 \text{ mm}$
γ beton	$= 2500 \text{ Kg/m}^3$
γ aspal	$= 2200 \text{ Kg/m}^3$
<i>Steeldeck</i>	$= 8,954 \text{ Kg/m}$

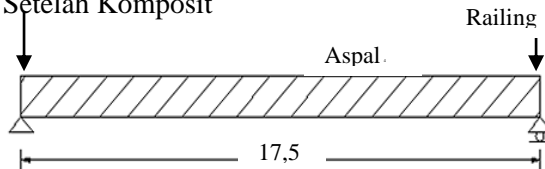
2) Beban Mati Sebelum Komposit



Gambar 5. 9 Pembebanan akibat beban mati

- Pelat (beton) $= B J_{\text{beton}} \times \lambda \times t_{\text{pelat}}$
 $= 25 \text{ Kg/m}^3 \times 17,5 \text{ m} \times 0,25 \text{ m}$
 $= 2500 \text{ kN/m}$
- Balok memanjang $= W \times \lambda / b1$
 $= 64,9 \text{ Kg/m} \times 4 \text{ m} / 1,75 \text{ m}$
 $= 148,34 \text{ Kg/m}$
- Berat *steeldeck* $= 8,95 \text{ Kg/m} \times \lambda$
 $= 8,95 \text{ Kg/m}^2 \times 4 \text{ m}$
 $= 36 \text{ Kg/m}$
- Berat profil $= 381,8/\text{m}$

Setelah Komposit



Gambar 5. 10 Pembeban akibat beban mati setelah komposit

- Aspal $= s. t \text{ aspal. } \gamma \text{ aspal}$
 $= 4 \text{ m. } 70 \text{ mm}/1000. 2200 \text{ Kg/m}^3$
 $= 616 \text{ Kg/m}$
- Railing $= 178,5 \text{ Kg/m}$

3) Beban Hidup

- BTR
 $\text{BTR} = \text{Untuk } L > 30 \text{ m}$
 $q = 9.0 (0.5 + 15/L) \text{ kPa}$
 $q = 9.0 (0.5 + 15/144) \text{ kPa}$
 $q = 544 \text{ Kg/m}^2$

$$\begin{aligned}
 q_{BTR} &= q \times s \\
 &= 5,44 \text{ kN/m}^2 \times 4 \text{ m} \\
 &= 2175 \text{ Kg/m}
 \end{aligned}$$

- BGT

DLA = 30 % untuk $L > 90 \text{ m}$

$$P_{BGT} = 4900 \text{ Kg/m}$$

$$\begin{aligned}
 P &= P_{BGT} (1 + DLA) \\
 &= 4900 \text{ Kg/m} (1 + 0,3) \\
 &= 6370 \text{ Kg}
 \end{aligned}$$

- Truk (T)

DLA = 0,3

$$T = 112,5 \text{ kN (R-SNI T-02-2005)}$$

Menurut R-SNI T-02-2005 Pasal 6.4.1 tentang besarnya beban truk "T" di tentukan:

$$\begin{aligned}
 T_u &= T \times (1 + DLA) \\
 &= 11250 \text{ Kg} \times (1 + 0,3) \\
 &= 14625 \text{ Kg}
 \end{aligned}$$

Tabel 5. 4 Rekapitulasi beban

JENIS BEBAN	NILAI	LF	TOTAL
Beban mati (sebelum Komposit)			
Balok memanjang	148.34	1.1	163.18 Kg/m'
Beban Profil	381.8	1.1	419.98 Kg/m'
Beban Pelat	2500	1.3	3250 Kg/m'
Beban Steldeck	36	1.4	50.14 Kg/m'
Beban mati (sesudah komposit)			
Beban aspal	616	1.3	800.8 Kg/m'
Beban railing	179	1.3	232.076 Kg
Beban hidup			
BTR	2175	1.8	3915 Kg/m'
BGT	6370	1.8	11466 Kg/m'
Truk	14625	1.8	26325 Kg

5.2.2 Perhitungan Momen

a. Beban Mati

Sebelum komposit

$$Q_{Total} = 3883,29 \text{ Kg/m}$$

$$\begin{aligned}
 M_{Q1} &= 1/8 \times Q_{DI} \times B^2 \\
 &= 1/8 \times 3883,29 \text{ Kg/m} \times (17,5 \text{ m})^2 \\
 &= 148658 \text{ Kgm}
 \end{aligned}$$

$$\begin{aligned}
 V_{Q1} &= 1/2 \times Q_{D1} \times B \\
 &= 1/2 \times 3883,29 \text{ Kg/m} \times 17,5\text{m} \\
 &= 33979 \text{ Kg}
 \end{aligned}$$

Setelah komposit

$$\sum M_B = 0$$

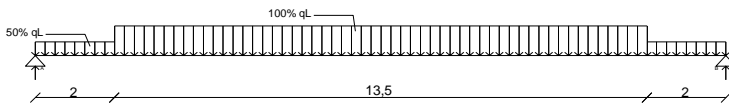
$$V_a \cdot 17,5 \text{ m} = (q_1 \times 17,5 \times 8,75\text{m}) + (q_2 \times (8,75 + 17,5))$$

$$V_a \cdot 17,5 \text{ m} = 113741,7 \text{ Kgm}$$

$$V_a = 6500 \text{ Kg}$$

$$\begin{aligned}
 M_{Q2} &= (v_a \times 8,75\text{m}) - (q_1 \times 8,75 \times 4,375\text{m}) - (q_2 \times 8,75\text{m}) \\
 &= 14207 \text{ Kgm}
 \end{aligned}$$

- b. Beban Hidup
- BTR + BGT



Gambar 5. 11 Pembebanan Akibat BTR dan BGT

Beban “D” = Beban BTR + Beban BGT

$$= 15381 \text{ Kg/m}$$

$$q_1 = 100\% \times D = 100\% \times 15381 \text{ Kg/m} = 15381 \text{ Kg/m}$$

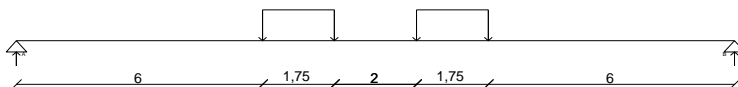
$$q_2 = 50\% \times D = 50\% \times 15381 \text{ Kg/m} = 7690,5 \text{ Kg/m}$$

$$\begin{aligned}
 V_a &= V_b \\
 &= 0,5(50\% q_1 \times L_{50}) + (100\% q_1 \times L_{100}) \\
 &= 119203 \text{ Kg}
 \end{aligned}$$

$$\begin{aligned}
 M_{\max} &= R_a \cdot L_1 - 50\% \cdot q_1 \cdot L_{50} \cdot L_2 - 100\% \cdot q_1 \cdot L_{100} \cdot L_3 \text{ kN/m} \\
 &= 573423 \text{ Kgm}
 \end{aligned}$$

- Beban truk “T”

Kondisi 1



Gambar 5. 12 Pembebanan Akibat Truk (Kondisi 1)

$$\sum M_B = 0$$

$$V_a \cdot 17,5 \text{ m} = T(6\text{m}+7,75\text{m}+9,75\text{m}+11,5\text{m})$$

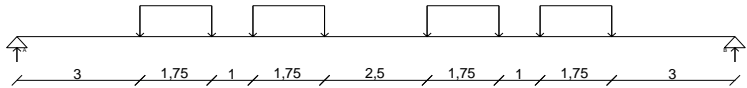
$$V_a \cdot 17,5 \text{ m} = 921375 \text{ Kg/m}$$

$$V_a = 52650 \text{ Kg}$$

$$M_{\max} = (V_a \times 8,75\text{m}) - T(1\text{m}+2,75\text{m})$$

$$M_{\max} = 144787,5 \text{ Kgm}$$

Kondisi 2



Gambar 5. 13 Pembebanan Akibat Truk (Kondisi 2)

$$\sum M_B = 0$$

$$V_a \cdot 17,5 \text{ m} =$$

$$T(3\text{m}+4,75\text{m}+5,75\text{m}+7,5\text{m}+10\text{m}+11,75\text{m}+12,75\text{m}+14,5\text{m})$$

$$V_a \cdot 17,5 \text{ m} = 1842750 \text{ Kg/m}$$

$$V_a = 105300 \text{ Kg}$$

$$M_{\max} = (V_a \times 8,75\text{m}) - T(1,25\text{m}+3\text{m}+4\text{m}+5,75\text{m})$$

$$M_{\max} = 552825 \text{ Kgm (menentukan)}$$

$$M_{\text{total}} = 14207 \text{ Kgm} + 573423 \text{ Kgm} + 552825 \text{ Kgm}$$

$$= 74625 \text{ Kgm}$$

5.2.3 Kontrol Kekuatan Lentur

- Tekuk lokal (RSNI T-03-2005 ps.7.2)

- Sayap

$$\lambda = \frac{bf}{2tf} = \frac{400}{2.38} = 5,26$$

$$\lambda_p = \frac{170}{\sqrt{fy}} = \frac{170}{\sqrt{410}} = 8$$

$$\lambda_r = \frac{370}{\sqrt{fy - fr}} = \frac{370}{\sqrt{410 - 70}} = 20$$

$$\lambda \leq \lambda_p \rightarrow \text{Penampang kompak}$$

- Badan

$$\lambda = \frac{h}{tw} = \frac{1060}{16} = 66,25$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} = \frac{1680}{\sqrt{410}} = 83$$

$$\lambda_r = \frac{2550}{\sqrt{f_y}} = \frac{2550}{\sqrt{410}} = 126$$

$$\lambda \leq \lambda_p \rightarrow \text{Penampang kompak}$$

Karena $\lambda > \lambda_p$ (penampang kompak) maka kuat lentur nominal penampang adalah $M_n = M_p = Z_x f_y$

$$M_p = M_n = Z_x \times f_y$$

$$= 22716000 \times 410$$

$$= 9313560000 \text{ Nmm} = 931356 \text{ Kgm}$$

$$M_u < \phi M_n$$

$$74625 \text{ Kgm} < 0,9 \times 931356 \text{ Kgm}$$

$$74625 \text{ Kgm} < 838220 \text{ Kgm (OK)}$$

- Tekuk lateral (RSNI T-03-2005 ps.7.3)

$$L = 1750 \text{ mm}$$

$$L_p = 1,76 \times i_y \sqrt{\frac{E}{f_y}}$$

$$= 1,76 \times 9,13 \sqrt{\frac{200000}{410}} = 3549 \text{ mm}$$

$$L \leq L_p \rightarrow \text{Bentang pendek}$$

$$M_p = M_n = Z_x \times f_y$$

$$= 22716000 \times 410$$

$$= 9313560000 \text{ Nmm} = 931356 \text{ Kgm}$$

Kapasitas momen :

$$\phi M_n = 0,9 \times 931356 \text{ Kgm}$$

$$= 838220 \text{ Kgm} > M_u = 746265 \text{ Kgm}$$

5.2.4 Kontrol Lendutan

Menurut RSNI T-03-2005 ps.4.7.2 menyatakan lendutan maksimum gelagar diatas dua tumpuan adalah $L/800$.

$$\delta_{ijin} = 1750/800 = 2,19 \text{ cm}$$

- a. Lendutan akibat beban hidup (BTR + BGT)

$$\begin{aligned}\delta_{(udl + kel)} &= \frac{5}{384} \times \frac{q_L \lambda^4}{E I_x} \\ &= \frac{5}{384} \times \frac{63,7 \times 1750^4}{2000000 \times 1215889} \\ &= 2,04 \text{ cm}\end{aligned}$$

- b. Lendutan akibat beban truk

$$\begin{aligned}\delta_{(T)} &= \frac{1}{48} \times \frac{P_T \lambda^3}{E I_x} \\ &= \frac{1}{48} \times \frac{14625 \times 1750^3}{2000000 \times 1215889} = 0,067 \text{ cm}\end{aligned}$$

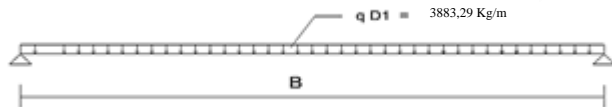
Dipakai beban dari lendutan yang lebih besar yaitu akibat beban Truk = 2,04 cm

$$\delta_{(T)} \leq \delta_{ijin}$$

$$2,04 \leq 2,19 \dots \text{ OK}$$

5.2.5 Kontrol Kekuatan Lentur Sebelum Komposit

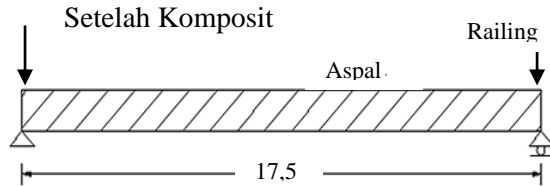
- a. Gaya geser sebelum komposit :



Gambar 5. 14 Beban geser sebelum komposit

$$\begin{aligned}V_{aD1} &= 0,5 \times Q_{D1} \times B \\ &= 0,5 \times 3883,29 \text{ Kg/m} \times 17,5 \text{ m} \\ &= 33979 \text{ Kg}\end{aligned}$$

b. Gaya geser setelah komposit :



Gambar 5. 15 Beban Merata Geser Setelah Komposit

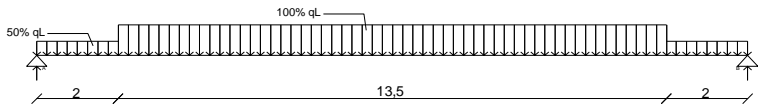
$$\sum M_B = 0$$

$$V_a \cdot 17,5 \text{ m} = (q_1 \times 17,5 \times 8,75 \text{ m}) + (q_2 \times 17,5)$$

$$V_a \cdot 17,5 \text{ m} = 126684 \text{ Kg m}$$

$$V_a = 7239 \text{ Kg}$$

c. Gaya geser akibat BTR+BGT tidak simetris :



Gambar 5. 16 Gaya Geser Akibat BTR+BGT Tak Simetris

“D” BTR 100% = 3915 Kg/m

BTR 50% = 1957,5 Kg/m

BGT 100% = 11466 Kg/m

BGT 50 % = 5733 Kg/m

- Untuk BTR

$$\sum M_B = 0$$

$$V_A \cdot 17,5 \text{ m} = (3915 \text{ Kg/m} \cdot 14,5 \text{ m}) \cdot 10,25 \text{ m} + (1957,5 \text{ Kg/m} \cdot 3 \text{ m}) \cdot 1,5 \text{ m}$$

$$V_A = 33753 \text{ Kg}$$

$$\sum M_A = 0$$

$$V_B \cdot 17,5 \text{ m} = (3915 \text{ Kg/m} \cdot 14,5 \text{ m}) \cdot 7,25 \text{ m} + (1957,5 \text{ Kg/m} \cdot 3 \text{ m}) \cdot 16 \text{ m}$$

$$V_B = 28887 \text{ Kg}$$

- Untuk BGT

$$\sum M_B = 0$$

$$V_A \cdot 17,5 \text{ m} = (11466 \text{ Kg/m} \cdot 14,5 \text{ m}) \cdot 10,25 \text{ m} + (5733 \text{ Kg/m} \cdot 3 \text{ m}) \cdot 1,5 \text{ m}$$

$$V_A = 98853 \text{ Kg}$$

$$\sum M_A = 0$$

$$V_B \cdot 17,5 \text{ m} = (11466 \text{ Kg/m} \cdot 14,5 \text{ m}) \cdot 7,25 \text{ m} + (5733 \text{ Kg/m} \cdot 3 \text{ m}) \cdot 16 \text{ m}$$

$$V_B = 84603 \text{ Kg}$$

$$\begin{aligned} \text{Maka } V_u &= V_{aDI} + V_{a(BTR)} + V_{a(BGT)} \\ &= 33978 \text{ Kg} + 33753 \text{ Kg} + 98853 \text{ Kg} \end{aligned}$$

$$V_u = 166585 \text{ Kg}$$

Jadi V_u yang digunakan sebesar 1110,8 kN. Maka kuat geser sebagai berikut (RSNI T-03-2005 ps.7.8) :

Luas penampang badan

$$\frac{h}{tw} = \frac{1060}{16} = 66,3$$

$$K_n = 5 + \frac{5}{\left(\frac{a}{h}\right)^2} = 28,75$$

$$1,10 \sqrt{\frac{K_n E}{f_y}} = \sqrt{\frac{28,75 \cdot 200000}{410}} = 130,3$$

$$\frac{h}{tw} \leq 1,10 \sqrt{\frac{K_n \times E}{f_y}}, \text{ maka kuat geser :}$$

$$V_u \leq \phi V_n$$

$$\begin{aligned} \phi V_n &= \phi \times 0,6 \times f_y \times A_w \\ &= 0,9 \times 0,6 \times 4100 \times (120 \times 1,6) \\ &= 425088 \text{ Kg} \\ &= 425088 \text{ Kg} \geq 166585 \text{ Kg} \end{aligned}$$

5.2.6 Kontrol Kekuatan Lentur Sesudah Komposit

Menurut SNI T-03-2005 ps. 8.2.1 lebar efektif pelat beton diambil nilai terkecil dari:

- 1/5 bentang gelagar
- Jarak antar gelagar

Dimana:

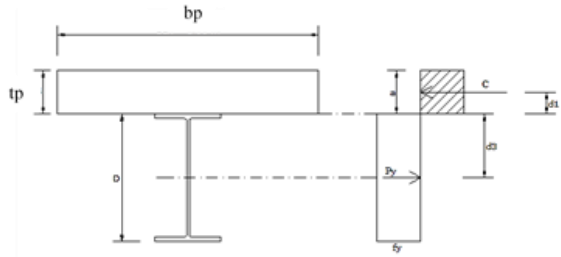
$L = 17500 \text{ mm}$ (panjang bentang)

$\lambda = 4000 \text{ m}$ (jarak antar gelagar memanjang)

$b_{eff} < L/5 = 17500/5 = 3500 \text{ mm}$

$$b_{eff} < s = 4000 \text{ mm}$$

diambil yang terkecil, $b_{eff} = 3500 \text{ mm}$



Gambar 5. 17 Distribusi Gaya pada Penampang

Sumber: RSNI T-03-2005 Gambar 12

- Kontrol kriteria penampang :

$$\frac{h}{tw} = \frac{1060}{16} = 66,25$$

$$\lambda_p = \frac{1680}{\sqrt{f_y}} = \frac{1680}{\sqrt{410}} = 83$$

$$\frac{h}{tw} \leq \frac{1680}{\sqrt{f_y}} \rightarrow \text{penampang kompak}$$

- Menentukan garis netral :

$$A_c = b_{eff} \times t_{plat} = 3500 \times 250 = 875000 \text{ mm}^2$$

$$C1 = A_s \times f_y = 48634 \times 410 = 19939940 \text{ N}$$

$$C2 = 0.85 f'_c \times A_c = 0.85 \times 40 \times 875000 = 28750000 \text{ N}$$

Sehingga nilai c diambil yang terkecil yaitu

$$C = 19939940 \text{ N}$$

$$a = \frac{c}{0.85 \cdot f'_c \cdot b_{eff}} = \frac{19939940}{0.85 \cdot 40 \cdot 3500} = 223,4 \text{ mm}$$

karena $a \leq t$ maka sumbu netral berada pada plat beton.

- Kapasitas momen :

$$d_1 = t - a/2 = 250 - 223,4/2 = 138,29 \text{ mm}$$

$$d_2 = 0 \text{ mm (Profil baja tidak mengalami tekan)}$$

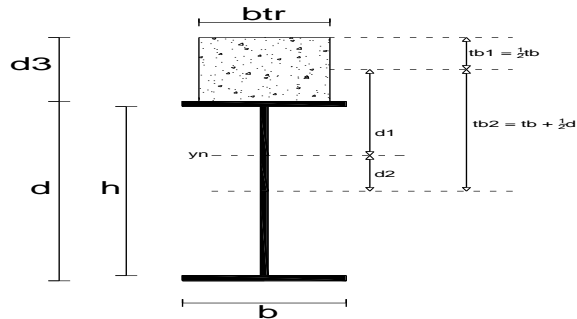
$$d_3 = d/2 = 1200/2 = 600 \text{ mm}$$

$$p_y = A_s \times f_y = 48634 \times 410 = 19939940 \text{ N}$$

$$M_n = C (d_1 + d_2) + p_y (d_3 - d_2)$$

$$\begin{aligned}
 &= 14721491257 \text{ Nmm} \\
 &= 1472149,1257 \text{ Kgm} \\
 \phi M_n &= 0,90 \times 1472149,1257 \text{ Kgm} \\
 &= 1324934 \text{ Kgm} \\
 &= 1324934 \text{ Kgm} > M_u = 746265 \text{ Kgm} \rightarrow \text{OK}
 \end{aligned}$$

Maka penampang telah memenuhi kekuatan lentur yang terjadi sesudah penampang komposit.



Gambar 5. 18 Gelagar Komposit

Menghitung momen inersia penampang

- Menentukan nilai n

$$E_s = 200000 \text{ MPa}$$

$$E_c = 29725 \text{ MPa}$$

$$\begin{aligned}
 n &= \frac{E_s}{E_c} \\
 &= 6,73
 \end{aligned}$$

- Luas konversi terhadap baja

$$b_{tr} = \frac{b_{eff}}{n} = \frac{350}{6,73} = 52 \text{ cm}$$

- Luas total (A_{tr})

$$\begin{aligned}
 A_{tr} &= b_{tr} \times t_{pelat} \\
 &= 52 \times 25 = 1300 \text{ cm}^2
 \end{aligned}$$

- $tb1 = \frac{1}{2} \times t_{pelat}$

$$= \frac{1}{2} \times 250 = 125 \text{ mm}$$

- $tb2 = t_{pelat} + (1/2 \times d)$

$$= 250 + (1/2 \times 1200) = 850 \text{ mm}$$

- Mencari garis netral

Tabel 5. 5 Garis Netral Penampang Komposit

	An (mm)	Jarak serat atas ke titik berat benda (tb1, tb2) (mm)	An x yn (mm ²)
Beton	130048.67	125	16256084
Baja	48634	850	41338900
Jumlah	178682.7	-	57594984

- $$Y_n = \frac{\sum A_n \cdot Y_n}{\sum A_n}$$

$$= \frac{57594984}{178682.7} = 322,3 \text{ mm}$$
- $$d_1 = Y_n - (1/2 \times t_{\text{pelat}})$$

$$= 322,3 + (1/2 \times 250) = 197,33 \text{ mm}$$
- $$d_2 = t_{b2} - Y_n$$

$$= 850 - 322,3 = 527,7 \text{ mm}$$

- Momen inersia penampang

Tabel 5. 6 Momen Inersia Penampang

	An	d	Io	Io + A d ²
Beton	130048.67	197.33	57600000000	62664039029
Baja	48634	527.7	12158892030	25700273253

$$I_{\text{total}} = 62664039029 \text{ mm}^4 + 25700273253 \text{ mm}^4$$

$$= 88364312282 \text{ mm}^4$$

5.2.7 Perhitungan Shear Connector

Untuk jarak perhitungan shear connector (RSNI T-03-2005 (8.6)) tidak boleh melebihi nilai sebagai berikut:

- 600 mm
- 2 x tebal lantai
- 4 x tinggi shear connector

Untuk diameter shear connector tidak boleh melebihi :

- 1,5 x tebal plat flens bila plat memikul tegangan tarik

- 2 x tebal plat flens bila tidak terdapat tegangan tarik
Digunakan shear connector jenis paku / stud (ARCFIX
Stud Welding) dengan data sebagai berikut:
- Diameter = 19 mm
- Tinggi = 150 mm
- $A_{sc} = 283,5 \text{ mm}^2$
- $f_c' = 40 \text{ MPa}$
- $E_c = 29725 \text{ MPa}$
- $F_u = 410 \text{ MPa}$

Kapasitas nominal 1 stud

$$\begin{aligned} Q_n &= 0,5 \times A_{sc} (f_c' \times E_c)^{0,5} \\ &= 0,5 \times 283,5 (40 \times 29725)^{0,5} \\ &= 154582,7 \text{ N} \end{aligned}$$

$$\begin{aligned} V_{ls} &= 0,55 \times 2 \times 154582 \text{ N} \\ &= 170041 \text{ N} \end{aligned}$$

Gaya geser yang bekerja:

$$V = 1665850,6 \text{ N}$$

Gaya geser persatuan panjang :

$$\begin{aligned} V_L &= \frac{V \times A_t \times Y_c}{I_t} \\ &= \frac{1665850,6 \times 1300,5 \times 19,7}{8836431,2} \\ &= 4837,9 \text{ N} \end{aligned}$$

$$V_L < \phi V_{ls}$$

$$4837,9 < 0,75 \times 170041$$

$$4837,9 < 127530,8 \text{ OK}$$

Jumlah shear connector :

$$\begin{aligned} V_h &= A_s \times f_y \\ &= 48634 \text{ mm}^2 \times 410 \text{ MPa} \\ &= 19939940 \text{ N} \end{aligned}$$

$$N = \frac{V_h}{Q_n} = \frac{19939940}{154582,7} = 129 \text{ buah} \approx 130 \text{ buah}$$

Jadi jumlah shear connector yang dibutuhkan sepanjang
gelagar memanjang adalah $2 \times n = 260$ buah

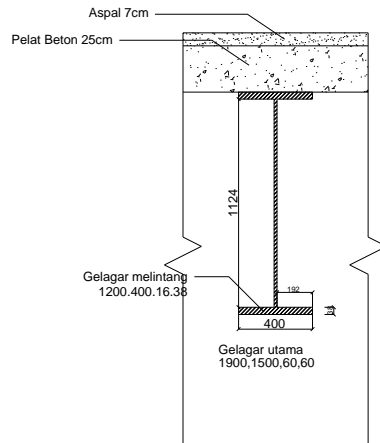
Jarak antar konektor yang digunakan

$$S = \frac{1750}{130} = 13 \text{ cm}$$

5.2.8 Perhitungan Sambungan Gelagar Melintang

a. Sambungan Las

Sambungan gelagar melintang terhadap *box girder* berupa sambungan las. Dalam perhitungan sambungan ini akan di hitung kekuatan sambungan las.



Gambar 5. 19 Sambungan gelagar melintang ke box girder

$$V_u = 166585 \text{ Kg}$$

$$M_u = 746265 \text{ Kgm}$$

Digunakan mutu las :

$$E120_{xx} = 120 \text{ Kips}$$

$$\text{Misal } t_e = 1 \text{ cm}$$

$$A = (4 \times 4.5 \times 1 \text{ cm}) + (1 \times 40.5 \times 1 \text{ cm}) + (2 \times 96.5 \times 1 \text{ cm}) + (4 \times 37.9 \times 1 \text{ cm}) = 413.3 \text{ cm}^2$$

Akibat V_u :

$$\begin{aligned} f_v &= \frac{V_u}{A} \\ &= \frac{166585}{403.1} \\ &= 413.3 \text{ kg/cm}^2 \end{aligned}$$

Akibat M_u :

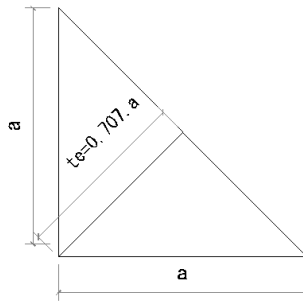
$$\begin{aligned}
 f_h &= \frac{M_u}{S_x} \\
 &= \frac{746265}{20264,82} \\
 &= 3683 \text{ kg/cm}^2
 \end{aligned}$$

$$\begin{aligned}
 f_{\text{total}} &= \sqrt{f_h^2 + f_v^2} \\
 &= \sqrt{3683^2 + 413,3^2} \\
 &= 3705,7 \text{ kg/cm}^2
 \end{aligned}$$

$$\begin{aligned}
 \phi f_n &= \phi \cdot 0,6 \cdot E120xx \\
 &= 0,75 \cdot 0,6 \cdot 120 \cdot 70,3 \text{ kg/cm}^2 \\
 &= 3796,2 \text{ kg/cm}^2
 \end{aligned}$$

$$\begin{aligned}
 t_{e\text{-perlu}} &= \frac{f_{\text{total}}}{\phi f_n} \cdot 1 \text{ cm} \\
 &= \frac{3705,7}{3796,2} \cdot 1 \text{ cm} \\
 &= 0,98 \text{ cm}
 \end{aligned}$$

$$\begin{aligned}
 a &= \frac{t_e}{0,707} \\
 &= 1,381 \text{ cm}
 \end{aligned}$$



b. Sambungan Baut

Sambungan baut dilakukan pada gelagar melintang dengan gelagar melintang pada jarak 275 cm dari tumpuan.

$$V_u = 1142,3 \text{ kN}$$

$$M_u = 3619,4 \text{ kNm (pada jarak 275cm dari tumpuan)}$$

Pembagian momen

$$\begin{aligned}
 M_{u\text{-badan}} &= \frac{I_{bd}}{I_{prop}} \cdot M_u \\
 &= \frac{\frac{1}{12} 16.120^3}{1215889} \cdot 3619,4 \\
 &= 685,84 \text{ kNm}
 \end{aligned}$$

$$\begin{aligned}
 M_{u\text{-sayap}} &= M_u - M_{u\text{-badan}} \\
 &= 3619,4 \text{ kNm} - 685,84 \text{ kNm} = 2933,6 \text{ kNm}
 \end{aligned}$$

Rencana :

Dbaut	= 3,6 cm
Dlubang	= 3,8 cm
Tb baut	= 490 kN
Pelat sambung (t)	= 15 mm

Baut mutu tinggi gesek

Koef. Gesek (μ) = 0,35

Jumlah bidang geser (m) = 1

ϕ = 0,9

kh = 1

$V_n = \mu \times m \times T_b \times k_h$
 $= 0,35 \cdot 1 \cdot 490 \cdot 1$
 $= 171,5 \text{ kN}$

$V_d = \phi \times V_n$
 $= 0,9 \cdot 171,5$
 $= 154,35 \text{ kN}$

1. Sambungan pelat sayap bawah

$M_u = 2933,6 \text{ kNm}$

$T_u = M_u/h$
 $= 2933,6/1,2$
 $= 2444,6 \text{ kN}$

$n = T_u/V_d$
 $= 2444,6/154,35$
 $= 15,8 \approx 16 \text{ buah}$

$T_u < n \cdot V_d$
 $2444,6 < 16 \cdot 154,35$
 $2444,6 < 2469,6 \text{ kN (OK)}$

Syarat jarak baut (RSNI T-03-2005)

Jarak ke tepi (S_1) = 1,5db s/d (4tp+100) atau 200mm

1,5 db = 1,5 . 36 mm = 5,4 cm

4tp+100 = (4 . 15 mm +100) = 16 cm

S_1 digunakan = 6 cm

Jarak antar baut (S) = 2,5 db s/d 15tp atau 200mm

2,5 db = 2,5 . 36 mm = 10,8 cm

$$15tp = 15 \cdot 15 \text{ mm} = 22,5 \text{ cm}$$

S digunakan = 11 cm

2. Sambungan pelat badan

$$Mu = 685,8 \text{ kNm}$$

Syarat jarak baut (RSNI T-03-2005)

Jarak ke tepi(S1) = 1,5db s/d (4tp+100) atau 200mm

$$1,5 \text{ db} = 1,5 \cdot 36 \text{ mm} = 5,4 \text{ cm}$$

$$4tp+100 = (4 \cdot 15 \text{ mm} + 100) = 16 \text{ cm}$$

S1 digunakan = 10 cm

Jarak antar baut(S) = 2,5 db s/d 15tp atau 200mm

$$2,5 \text{ db} = 2,5 \cdot 36 \text{ mm} = 10,8 \text{ cm}$$

$$15tp = 15 \cdot 15 \text{ mm} = 22,5 \text{ cm}$$

S digunakan = 11 cm

$$n = \sqrt{\frac{6M_{\text{utot}}}{\mu R_u}}$$

Dimana :

n = jumlah baut

M_{utot} = Momen total

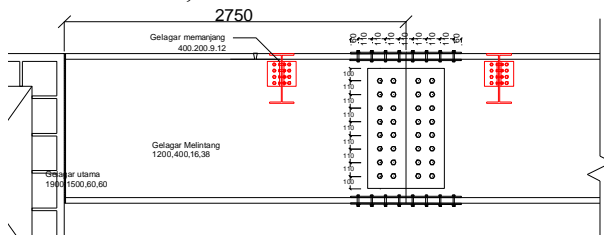
μ = Jarak verikal baut

= 100 mm

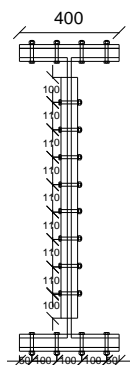
R_u = Kapasitas baut

$$n = \sqrt{\frac{6.685,8}{0,11.154,35}}$$

$$= 15,6 \text{ buah} \approx 16 \text{ buah}$$



Gambar 5. 20 Sambungan gelagar melintang (mm)



Gambar 5. 21 Detail melintang sambungan baut (mm)



Shear Connectors

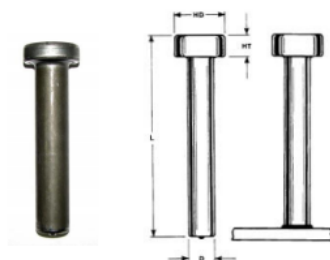
Headed Shear Connectors are used as an essential component in composite beam design and construction.

Shank Diameter (d)	Length (L) tolerance	Head Diameter tolerance	Minimum head height HT
19.0 +0.00 -0.38	±1.6	31.7 ± 0.4	9.5
22.2 +0.00 -0.38	±1.6	34.9 ± 0.4	9.5

Material	LOW CARBON STEEL AS1445 S1010 to S1020 Or K1010 to K1020		
Mechanical Properties	Tensile Yield Elongation Reduction of area	410MPa (min) 345MPa (min) 12% 50% (min)	

Shear Connectors

Size	Part Number	Pack Size
13 X 50	ESC11-13-050	250
13 X 75	ESC11-13-075	150
13 X 100	ESC11-13-100	125
16 X 75	ESC11-16-075	125
16 X 100	ESC11-16-100	100
16 X 150	ESC11-16-150	75
19 X 75	ESC11-19-075	100
19 X 95	ESC11-19-095	75
19 X 100	ESC11-19-100	75
19 X 105	ESC11-19-105	75
19 X 115	ESC11-19-115	60
19 X 120	ESC11-19-120	60
19 X 127	ESC11-19-127	60
19 X 150	ESC11-19-150	50
19 X 178	ESC11-19-178	45
19 X 198	ESC11-19-198	40
22 X 100	ESC11-22-100	50
22 X 125	ESC11-22-125	50
22 X 150	ESC11-22-150	40
22 X 178	ESC11-22-178	40
22 X 198	ESC11-22-198	35



FERRULE

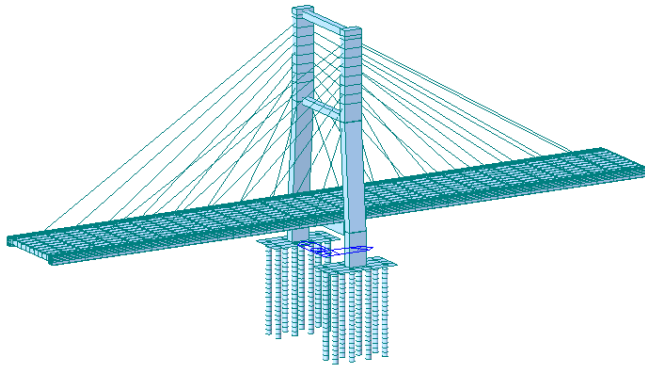


Note Ferrules are a component part of studs and not sold separately

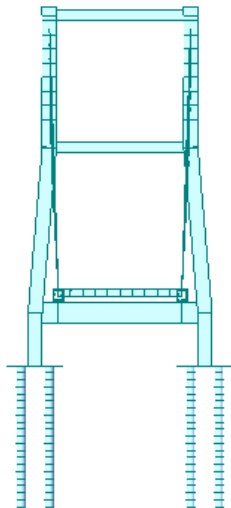
Gambar 5. 22 Profil Shear Connector

5.3 Permodelan Struktur

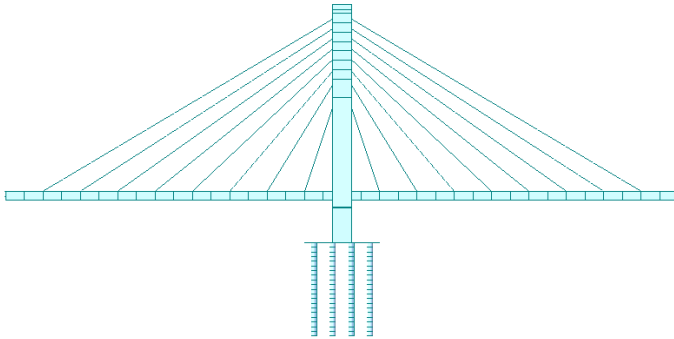
Permodelan struktur jembatan ini akan digunakan program bantu MIDAS CIVIL V2011. Dibahas mulai dari permodelan struktur, pembebanan, dan analisa struktur. Digunakan pembebanan statik, dan dinamis. menggunakan permodelan dengan tiga dimensi, untuk lebih jelasnya seperti pada Gambar 7.1 sampai dengan Gambar 7.5 berikut ini :



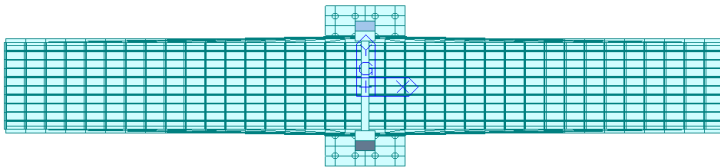
Gambar 5. 23 Tampak perspektif jembatan



Gambar 5. 24 Tampak melintang jembatan



Gambar 5. 25 Tampak memanjang jembatan



Gambar 5. 26 Tampak atas jembatan



Gambar 5. 27 Tampak melintang dek jembatan

5.3.1 Analisa Statik

Beberapa beban yang termasuk beban statik antara lain beban tetap (berat sendiri dan beban mati tambahan), beban hidup, dan beban angin. Untuk beban sendiri struktur seperti box girder, pylon, dan kabel akan hitung secara otomatis oleh program bantu MIDAS CIVIL 2011.

1. Beban mati

a) Beban sebelum komposit

$$P = q \cdot \text{jarak antar gelagar melintang} \\ = 36 \text{ kg/m}$$

b) Beban setelah komposit

- Berat aspal = 616 Kg/m
- Berat railing = 179 Kg/m

2. Beban Hidup

a) Beban Terbagi Rata (BTR)

Untuk $L \leq 30$ m : $q = 9$ kPa

$$\text{Untuk } L > 30 \text{ m : } q = 9,0 \left(0,5 + \frac{15}{L} \right) \text{ kPa}$$

(SNI 1725-2016 pasal. 8.3.1)

Karena L pada desain ini = 144 m. maka

$$q = 9,0 \left(0,5 + \frac{15}{147} \right) \text{ kPa}$$

$$= 544 \text{ kPa}$$

$$= 544 \text{ Kg/m}^2$$

$$q = q_{\text{BTR}} \cdot 4\text{m}$$

$$= 544 \text{ Kg/m}^2 \cdot 4\text{m}$$

$$= 2175 \text{ Kg/m}$$

b) Beban Garis Terpusat (BGT)

Menurut SNI 1725-2016 pasal 8.3.1 besarnya BGT adalah 49 kN/m. Dengan bentang total jembatan pada desain ini adalah 144 m maka nilai Faktor Beban Dinamis (FDB) diambil sebesar 30% (Gambar 28 SNI 1725-2016)

$$P = P_{\text{BGT}} (1 + \text{FDB})$$

$$= 49 \text{ kN/m} (1 + 30\%)$$

$$= 6370 \text{ Kg/m}$$

3. Beban Angin

a) Beban angin pada struktur

Berdasarkan SNI 1725-2016 pasal 9.6.1, tekanan angin horizontal untuk bagian jembatan dengan elevasi lebih tinggi dari 10000 mm di atas permukaan tanah atau permukaan air maka kecepatan angin rencana, V_{DZ} , sebagai berikut

$$V_{\text{DZ}} = 2,5 \cdot V_0 \left(\frac{V_{10}}{V_B} \right) \ln \left(\frac{Z}{Z_0} \right)$$

Dimana :

V_{DZ} = kecepatan angin rencana pada elevasi rencana, Z (km/jam)

V_{10} = kecepatan angin pada elevasi 10000 mm di atas permukaan tanah atau di atas permukaan air rencana (km/jam)

V_B = kecepatan angin rencana yaitu 90 hingga 126 km/jam pada elevasi 10000 mm yang akan menghasilkan tekanan

Z = elevasi struktur diukur dari permukaan tanah atau dari permukaan air dimana beban angin dihitung ($Z > 10000$ mm)

V_0 = kecepatan gesekan angin, yang merupakan karakteristik meteorologi, ditentukan dalam Tabel 7.1

Z_0 = panjang gesekan di hulu jembatan, yang merupakan karakteristik meteorologi ditentukan dalam Tabel 7.1

V_{10} dapat diperoleh dari :

- Grafik kecepatan angin dasar untuk berbagai periode ulang
- Survey angin pada lokasi jembatan
- Jika tidak ada data yang lebih baik maka perencanaan dapat mengasumsikan bahwa $V_{10} = V_B = 90$ s/d 126 km/jam

Tabel 5. 7 Nilai V_0 dan Z_0 untuk variasi kondisi permukaan hulu

Kondisi	Lahan Terbuka	Sub Urban	Kota
V_0 (km/jam)	13,2	17,6	19,3
Z_0 (mm)	70	1000	2500

$$\begin{aligned}
 V_{DZ} &= 2,5 \cdot 13,2 \left(\frac{100}{100} \right) \ln \left(\frac{11000}{70} \right) \\
 &= 167 \text{ km/jam} \\
 &= 46,36 \text{ m/s}
 \end{aligned}$$

Dengan mengetahui kecepatan angin yang bekerja, dapat ditentukan beban angin pada struktur dimana tekanan angin rencana dalam MPa dengan menggunakan persamaan

$$P_D = P_B \left(\frac{V_{DZ}}{V_B} \right)^2$$

Dimana :

P_B = tekanan angin dasar yang ditentukan dalam Tabel 5.8

Tabel 5. 8 Tekanan angin dasar

Komponen bangunan atas	Angin tekan (MPa)	Angin hisap (MPa)
Rangka, kolom, dan pelengkung	0,0024	0,0012
Balok	0,0024	N/A
Permukaan datar	0,0019	N/A

$$\begin{aligned} P_D &= 0,0024 \cdot \left(\frac{166,89}{100} \right)^2 \\ &= 0,00310 \text{ MPa} \\ &= 310,04 \text{ Kg/m}^2 \end{aligned}$$

Beban pada struktur akan diterima pada gelegar utama yang berupa *box girder* sehingga dikalikan dengan tinggi penampang *box girder*.

$$\begin{aligned} P_D &= 310,04 \text{ Kg/m}^2 \cdot 1,9 \text{ m} \\ &= 589,08 \text{ Kg/m} \\ &= 5,9 \text{ kN/m} \end{aligned}$$

$$P_D > P_{Dmin}$$

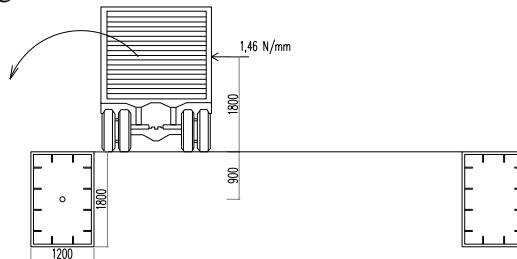
$$5,9 \text{ kN/m} > 4,4 \text{ kN/m (SNI 1725-2016 pasal 9.6.1.1)}$$

b) Beban angin pada kendaraan

Beban angin juga akan dibebankan pada kendaraan yang melintas (EW_1) dimana telah diatur di SNI 1725-2016 pasal 9.6.1.2 dengan asumsi sebagai tekanan yang menerus sebesar 1,46 N/mm yang bekerja tegak lurus dan bekerja diatas 1800mm diatas permukaan jalan. Maka beban angin pada kendaraan yang akan diinput.

$$\begin{aligned} EW_1 &= 1,46 \text{ N/mm} \\ &= 1,46 \text{ kN/m} \cdot (\text{tinggi} + 1/2 t_{\text{box girder}}) \cdot \text{panjang segmen} \\ &= 1,46 \text{ kN/m} \cdot (1,9 \text{ m} + 0,95 \text{ m}) \cdot 4 \text{ m} \\ &= 16,644 \text{ kNm} \\ &= 1664,4 \text{ Kgm} \end{aligned}$$

Untuk beban angin pada kendaraan akan diinput sebagai momen torsi.



Gambar 5. 28 Ilustrasi beban angin kendaraan menjadi momen torsi

4. Beban Temperatur

Sesuai dengan SNI 1725-2016 pasal 9.3.1 dimana deformasi akibat perubahan temperatur yang merata. Perbedaan antara temperatur minimum atau temperatur maksimum dengan temperatur nominal yang diasumsikan dalam perencanaan harus digunakan untuk menghitung pengaruh akibat deformasi yang terjadi akibat perbedaan suhu.

Tabel 5. 9 Sifat bahan rata-rata akibat pengaruh temperatur

Bahan	Koefisien perpanjangan akibat suhu (α)	Modulus Elastisitas (MPa)
Baja	12×10^{-6} per $^{\circ}\text{C}$	200.000
Beton:		
Kuat tekan <30 MPa	10×10^{-6} per $^{\circ}\text{C}$	$4700\sqrt{f_c'}$
Kuat tekan >30 MPa	11×10^{-6} per $^{\circ}\text{C}$	$4700\sqrt{f_c'}$

Tabel 5. 10 Temperatur jembatan rata-rata nominal

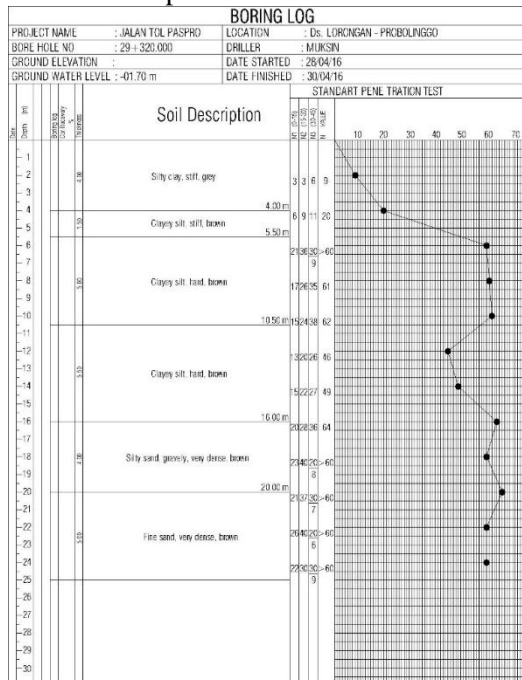
Tipe bangunan atas	Temperatur jembatan rata-rata minimum (1)	Temperatur jembatan rata-rata maksimum
Lantai beton di atas gelagar atau boks beton.	15°C	40°C
Lantai beton di atas gelagar, boks atau rangka baja.	15°C	40°C
Lantai pelat baja di atas gelagar, boks atau rangka baja.	15°C	45°C

CATATAN (1) Temperatur jembatan rata-rata minimum bisa dikurangi 5°C untuk lokasi yang terletak pada ketinggian lebih besar dari 500 m diatas permukaan laut.

Jadi dipakai temperature minimal jembatan 15°C dan temperature maksimal 40°C .

5.3.2 Analisa Dinamik

Dalam analisa beban gempa digunakan acuan SNI 2833-2016 dimana akan menghasilkan *response spectrum* yang nanti dimasukkan ke dalam permodelan di MIDAS CIVIL.



Gambar 5. 29 Data Tanah Untuk Menentukan Jenis Tanah

Tahanan penetrasi standar lapangan rata-rata \bar{N}

$$\bar{N} = \frac{\sum di}{\sum di/N_i} = \frac{30}{0,945} = 31,7$$

Kondisi tanah dimasukkan dalam katagori (tanah sedang) dikarenakan $15 < N < 50$

Tabel 5. 11 Koefisien Situs, F_a dan Koefisien Situs, F_v

Tabel 3 - Faktor amplifikasi untuk PGA dan 0,2 detik (F_{PGA}/F_s)

Kelas situs	PGA $\leq 0,1$ $S_s \leq 0,25$	PGA = 0,2 $S_s = 0,5$	PGA = 0,3 $S_s = 0,75$	PGA = 0,4 $S_s = 1,0$	PGA > 0,5 $S_s \geq 1,25$
Batuan Keras (SA)	0,8	0,8	0,8	0,8	0,8
Batuan (SB)	1,0	1,0	1,0	1,0	1,0
Tanah Keras (SC)	1,2	1,2	1,1	1,0	1,0
Tanah Sedang (SD)	1,6	1,4	1,2	1,1	1,0
Tanah Lunak (SE)	2,5	1,7	1,2	0,9	0,9
Tanah Khusus (SF)	SS	SS	SS	SS	SS

Catatan : Untuk nilai-nilai antara dapat dilakukan interpolasi linier

Keterangan:

PGA adalah percepatan puncak batuan dasar sesuai peta percepatan puncak di batuan dasar (PGA) untuk probabilitas terlampaui 7% dalam 75 tahun (Gambar 1).

S_s adalah parameter respons spektra percepatan gempa untuk periode pendek ($T=0,2$ detik) dengan probabilitas terlampaui 7% dalam 75 tahun sesuai dengan Gambar 2.

SS adalah lokasi yang memerlukan investigasi geoteknik dan analisis respons dinamik spesifik.

Tabel 4 - Besarnya nilai faktor amplifikasi untuk periode 1 detik (F_1)

Kelas situs	$S_1 \leq 0,1$	$S_1 = 0,2$	$S_1 = 0,3$	$S_1 = 0,4$	$S_1 \geq 0,5$
Batuan Keras (SA)	0,8	0,8	0,8	0,8	0,8
Batuan (SB)	1,0	1,0	1,0	1,0	1,0
Tanah Keras (SC)	1,7	1,6	1,5	1,4	1,3
Tanah Sedang (SD)	2,4	2,0	1,8	1,6	1,5
Tanah Lunak (SE)	3,5	3,2	2,8	2,4	2,4
Tanah Khusus (SF)	SS	SS	SS	SS	SS

Catatan : Untuk nilai-nilai antara dapat dilakukan interpolasi linier

Keterangan:

S_1 adalah parameter respons spektra percepatan gempa untuk periode 1 detik dengan probabilitas terlampaui 7% dalam 75 tahun sesuai dengan Gambar 3.

SS adalah lokasi yang memerlukan investigasi geoteknik dan analisis respons dinamik spesifik

Tabel 5. 12 Tabel Zona Gempa

Tabel 5 - Zona gempa

Koefisien percepatan (S_{D1})	Zona gempa
$S_{D1} \leq 0,15$	1
$0,15 < S_{D1} \leq 0,30$	2
$0,30 < S_{D1} \leq 0,50$	3
$S_{D1} > 0,50$	4

Catatan : $S_{D1} = F_v \times S_1$

S_{D1} adalah nilai spektra permukaan tanah pada periode 1,0 detik

F_v adalah nilai faktor amplifikasi untuk periode 1 detik (F_1)

S_1 adalah parameter respons spektra percepatan gempa untuk periode 1,0 detik mengacu pada Peta Gempa Indonesia dengan probabilitas terlampaui 7% dalam 75 tahun (Gambar 3).

Dari peta zonasi gempa diatas didapatkan:

- PGA = 0,3
- S_s = 0,7
- S_{D1} = 0,3
- F PGA = 1,2
 - F_v = 1,8
 - F_a = 1,2
 - Zona gempa 4

$$\begin{aligned}
 A_s &= F \text{ PGA. PGA} \\
 &= 1,2. 0,3 \\
 &= 0,36
 \end{aligned}$$

$$\begin{aligned}
 SDs &= Fa. Ss \\
 &= 1,2. 0,7 \\
 &= 0,84
 \end{aligned}$$

$$\begin{aligned}
 SD1 &= Fv. SD1 \\
 &= 1,8. 0,3 \\
 &= 0,54
 \end{aligned}$$

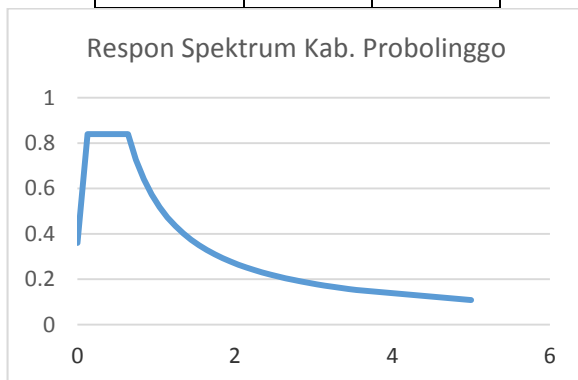
$$\begin{aligned}
 T0 &= 0,2. Ts \\
 &= 0,129 \text{ detik}
 \end{aligned}$$

$$\begin{aligned}
 Ts &= \frac{SD1}{SDs} \\
 &= \frac{0,54}{0,84} \\
 &= 0,643 \text{ detik}
 \end{aligned}$$

Tabel 5. 13 Perhitungan Respon Spektrum

T(Detik)	T(detik)	As(g)
0	0	0.36
T0	0.129	0.84
Ts	0.643	0.84
Ts+0.1	0.743	0.727
Ts+0.2	0.843	0.641
Ts+0.3	0.943	0.573
Ts+0.4	1.043	0.518
Ts+0.5	1.143	0.473
Ts+0.6	1.243	0.434
Ts+0.7	1.343	0.402
Ts+0.8	1.443	0.374
Ts+0.9	1.543	0.350
Ts+1.0	1.643	0.329
Ts+1.1	1.743	0.310
Ts+1.2	1.843	0.293
Ts+1.3	1.943	0.278
Ts+1.4	2.043	0.264

Ts+1.5	2.143	0.252
Ts+1.6	2.243	0.241
Ts+1.7	2.343	0.230
Ts+1.8	2.443	0.221
Ts+1.9	2.543	0.212
Ts+2.0	2.643	0.204
Ts+2.1	2.743	0.197
Ts+2.2	2.843	0.190
Ts+2.3	2.943	0.183
Ts+2.4	3.043	0.177
Ts+2.5	3.143	0.172
Ts+2.6	3.243	0.167
Ts+2.7	3.343	0.162
Ts+2.8	3.443	0.157
Ts+2.9	3.543	0.152
5	5	0.063



Gambar 5. 30 Grafik response spectrum

Dari perhitungan di atas didapat nilai respon spektra, maka nilai respon spektra perlu direduksi menurut SNI 2833:2016 zona gempa 4.

Tabel 5. 14 Faktor modifikasi

Tabel 6 - Faktor modifikasi respon (*R*) untuk bangunan bawah

Bangunan bawah	Kategori kepentingan		
	Sangat penting	Penting	Lainnya
Pilar tipe dinding	1,5	1,5	2,0
Tiang/kolom beton bertulang			
Tiang vertikal	1,5	2,0	3,0
Tiang miring	1,5	1,5	2,0
Kolom tunggal	1,5	2,0	3,0
Tiang baja dan komposit			
Tiang vertikal	1,5	3,5	5,0
Tiang miring	1,5	2,0	3,0
Kolom majemuk	1,5	3,5	5,0

Catatan:

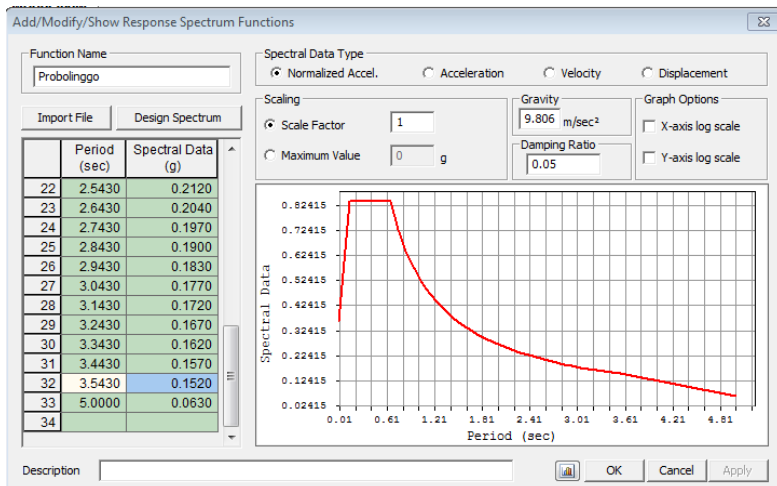
Pilar tipe dinding dapat direncanakan sebagai kolom tunggal dalam arah sumbu lemah pilar

Koefisien *R* pada jembatan diambil sebagai berikut:

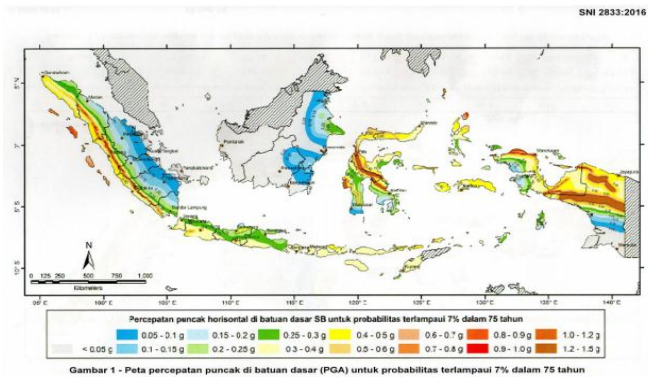
R=1 untuk pondasi

R=2 untuk kolom tunggal

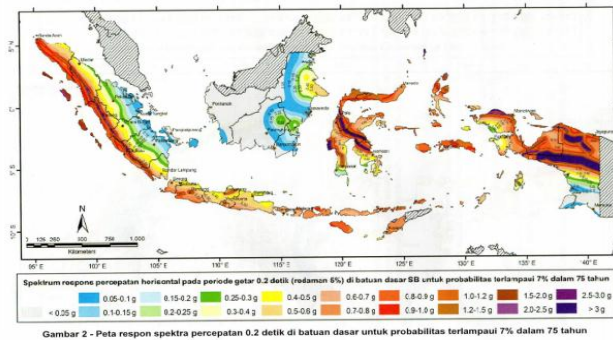
R=3,5 untuk kolom majemuk



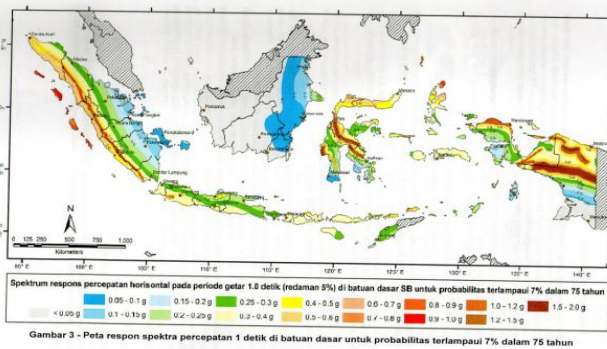
Gambar 5. 31 Grafik response spectrum pada MIDAS CIVIL



SNI 2833:2016



SNI 2833:2016



Gambar 5. 32 Peta respon spektra Indonesia

5.3.3 Kombinasi Beban

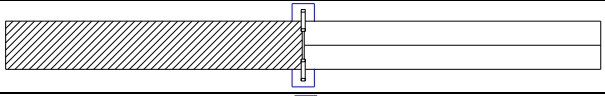
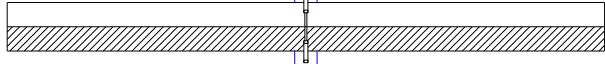
5.3.3.1 Kombinasi Beban Analisa Statik

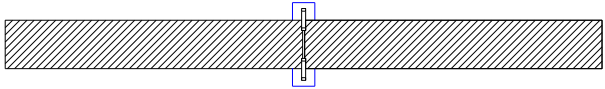
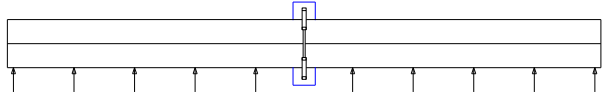
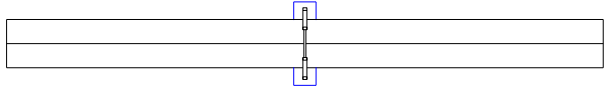
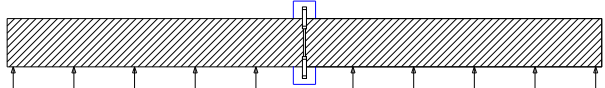
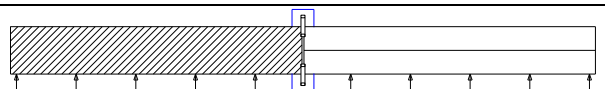
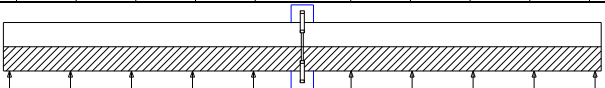
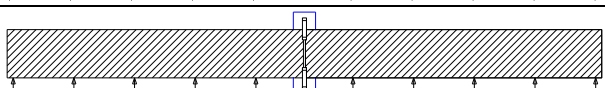
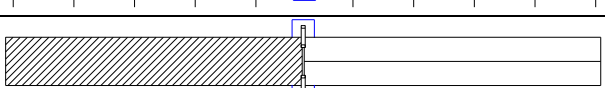
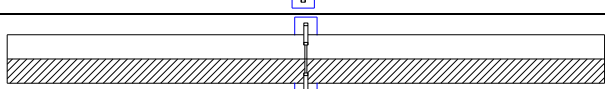
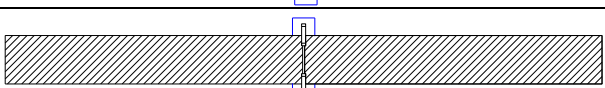
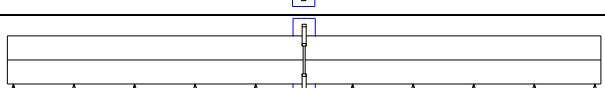
Tabel 5. 15 Kombinasi pembebanan untuk analisa statik

Kasus	Konfigurasi Beban
1	$1,1DL+2ADL+2TD+0,5E_{un}$
2	$1,1DL+2ADL+2TD+0,5E_{un}$
3	$1,1DL+2ADL+2TD+0,5E_{un}$
4	$1,1DL+2ADL+1,4EW_s+0,5E_{un}$
5	$1,1DL+2ADL+0,5E_{un}$
6	$1,1DL+2ADL+0,4EW_s+EW_l+E_{un}$
7	$DL+ADL+TD+EW_s+E_{un}$
8	$DL+ADL+TD+EW_l+E_{un}$
9	$DL+ADL+TD+EW_l+E_{un}$
10	$DL+ADL+1,3TD+1,3TB+1,3TP+E_{un}$
11	$DL+ADL+1,3TD+1,3TB+1,3TP+E_{un}$
12	$DL+ADL+1,3TD+1,3TB+1,3TP+E_{un}$
13	$DL+ADL+0,7EW_s+E_{un}$

Keterangan	
DL	Berat Sendiri
ADL	Beban Mati Tambahan
TD	Beban "D" (BTR & BGT)
BTR	Beban Terbagi Rata
BGT	Beban Garis Terpusat
EW_s	Beban Angin pada struktur
EW_l	Beban Angin pada Beban hidup
E_{un}	Temperatur Seragam

Tabel 5. 16 Ilustrasi dari konfigurasi beban tampak atas

Kasus	Ilustrasi
1	
2	

3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

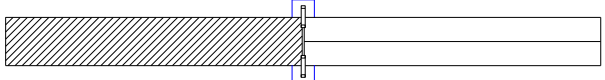
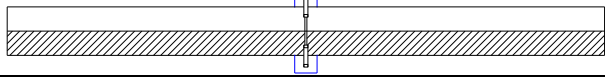
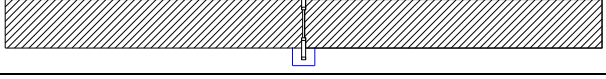
5.3.3.2 Konfigurasi Beban Analisa Dinamis

Berikut ini konfigurasi beban untuk analisa dinamik yang berupa beban gempa *response spectrum* dan beban tetap dapat dilihat pada Tabel.

Tabel 5. 17 Kombinasi pembebanan untuk analisa dinamik

Kasus	Konfigurasi Beban
14	1,1DL+2ADL+0,3TD+Ex+0,3Ey
15	1,1DL+2ADL+0,3TD+Ex+0,3Ey
16	1,1DL+2ADL+0,3TD+Ex+0,3Ey

Tabel 5. 18 Ilustrasi dari konfigurasi beban tampak atas

Kasus	Ilustrasi
14	
15	
16	

5.3.4 Pembebanan Kabel

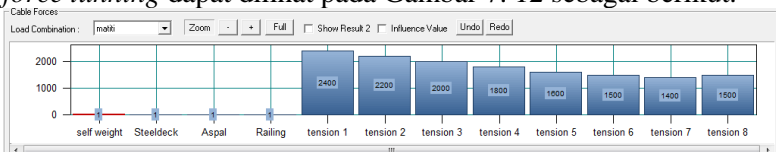
Dalam pelaksanaannya, pada tiap kabel akan diberikan gaya tarik sebelum dibebani. Dengan adanya gaya tarik terlebih dahulu agar dapat mengatur posisi akhir pada gelagar sebelum diberi beban. Bila kabel tidak dibebani terlebih dahulu akan mengakibatkan gelagar akan melendut terlebih dahulu sebelum adanya beban yang bekerja pada lantai kendaraan.

Dengan adanya program MIDAS CIVIL yang dapat membantu menganalisa besarnya gaya tarik pada tiap kabel dengan salah satu fitur yang ada yaitu *unknown load factor calculation*. Berikut ini langkah-langkah dalam melakukan analisa gaya tarik pada tiap kabel dapat dijelaskan sebagai berikut ini:

1. Memberikan gaya tarik (*stressing*) pada kabel sebesar 1 kN pada tiap kabel.

2. Memberikan batasan deformasi untuk tiap nodal pada lantai kendaraan. Hal ini dimaksudkan untuk memberikan input program kondisi akhir yang diinginkan untuk lantai kendaraan. Batasan yang diberikan sebesar $+0,01$ m dan $-0,01$ m. Hal tersebut dilakukan agar mendapatkan hasil akhir pada lantai kendaraan yang melendut sebesar $0,01$ m setelah dilakukan penarikan kabel.
3. Ditentukan beban-beban yang bekerja yang dapat mempengaruhi hasil akhir sebelum adanya beban hidup. Beban-beban yang bekerja antara lain adalah beban mati (berat sendiri lantai kendaraan) dan beban mati tambahan.
4. Data yang telah diperlukan oleh program MIDAS CIVIL sehingga dapat melakukan iterasi. Program tersebut akan melakukan iterasi dari gaya yang diberikan sebelumnya sebesar 1 kN dengan batasan yang diberikan yaitu $0,01$ m pada lantai kendaraan.
5. Hasil dari analisa adalah *load factor* untuk tiap kabel. Dari gaya tarik sebesar 1 kN diberikan *load factor* oleh program MIDAS CIVIL dari hasil iterasi. Hal ini berhubungan dengan salah satu fitur adalah *unknown load factor calculation*.

Hasil iterasi pada tiap gaya kabel yang diperoleh dari *cable force tuning* dapat dilihat pada Gambar 7. 12 sebagai berikut.

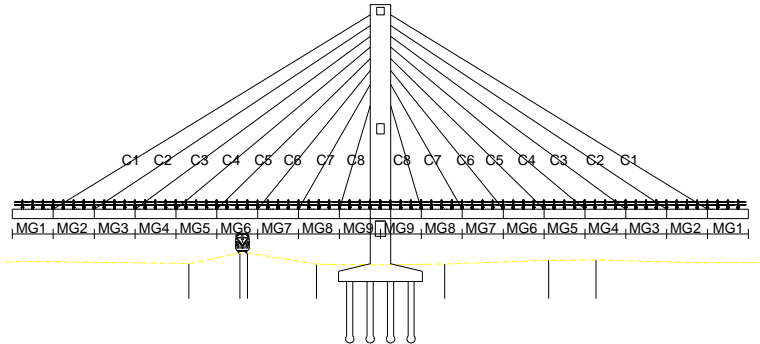


Gambar 5. 33 Gaya tarik awal tiap kabel

5.3.5 Staging analysis

Staging analysis merupakan salah satu fitur dari program bantu MIDAS CIVIL dimana dapat simulasikan metode

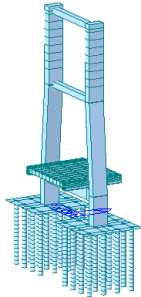
pelaksanaan yang menggunakan *balance cantilever* dan dipengaruhi oleh beban *form traveler* dan lantai kendaraan. Sebelum dimodelkan, beban yang bekerja seperti *form traveler* dan lantai kendaraan akan dihitung. Karena *form traveler* akan mengangkat lantai kendaraan.



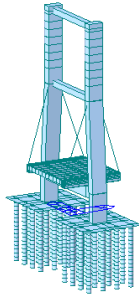
Gambar 5. 34 Segmental deck untuk staging analysis

5.3.6 Pelaksanaan

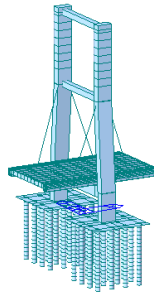
- 1) Pembangunan jembatan dimulai dengan struktur bawah dan pylon kemudian dilanjutkan dengan pemasangan (Main Girder) MG9 menggunakan crane, kemudian ditempatkan diatas perancah sementara



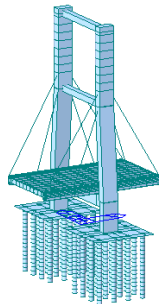
2) Pemasangan (Cable) C8



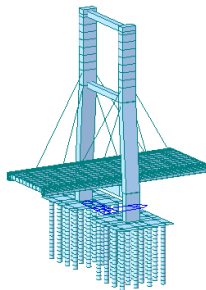
3) Pemasangan GMG8



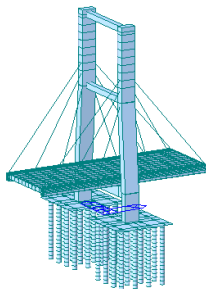
4) Pemasangan C7



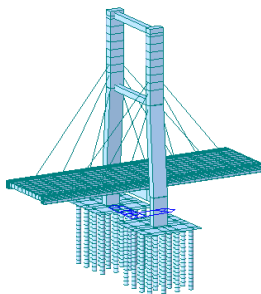
5) Pemasangan MG7



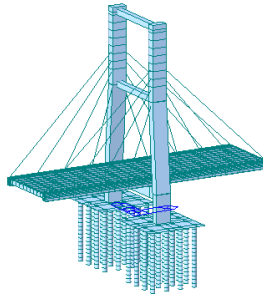
6) Pemasangan C6



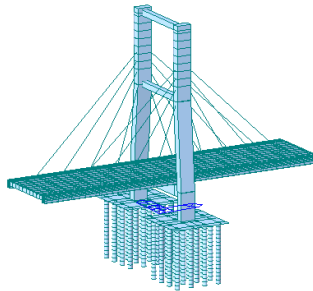
7) Pemasangan MG6



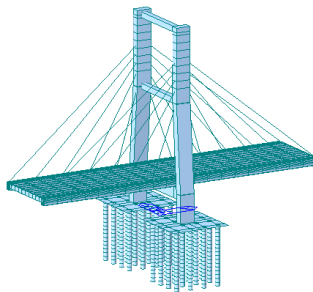
8) Pemasangan C5



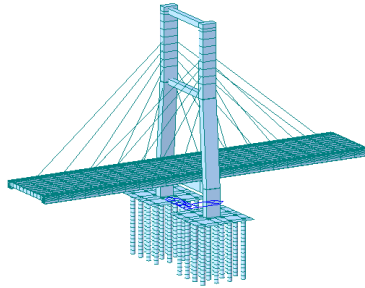
9) Pemasangan MG5



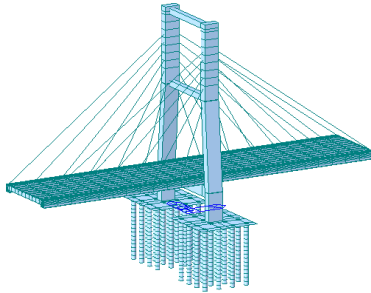
10) Pemasangan C4



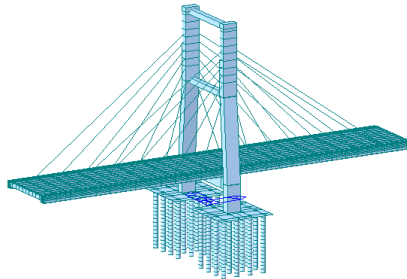
11) Pemasangan MG4



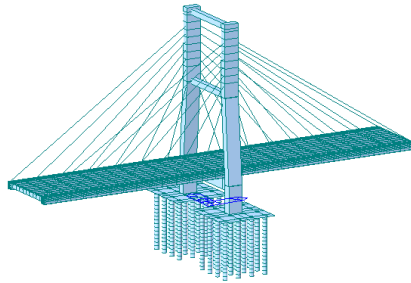
12) Pemasangan C3



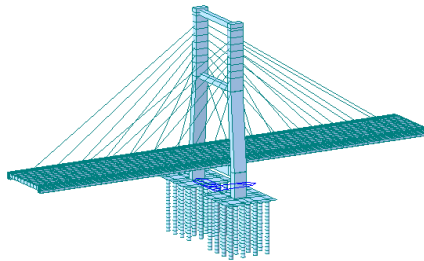
13) Pemasangan MG3



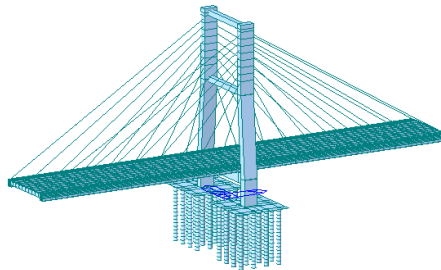
14) Pemasangan C2



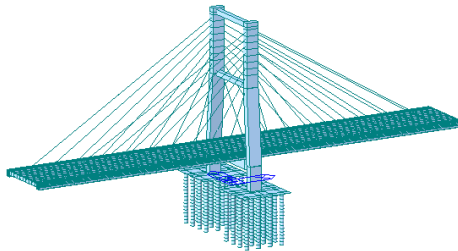
15) Pemasangan MG2



16) Pemasangan C1



17) Pemasangan MG1



5.3.7 Pembebanan

Untuk melakukan *staging analysis*, terlebih dahulu dilakukan perhitungan pembebanan untuk form traveler dengan beban rantai kendaraan.

1. Beban form traveler (P_{FT})

Pada pelaksanaan akan menggunakan *form traveler* dengan tipe *overhead*. *Form traveler* akan membebani struktur yang berupa *balace cantilever*.



Gambar 5. 35 Contoh form traveler yang digunakan
Spesifikasi form traveler menggunakan dari Handan China Railway Bridge Machinery Co. Ltd., berikut spesifikasi form traveler :

Tabel 5. 19 FT-S form traveler overhead model specification

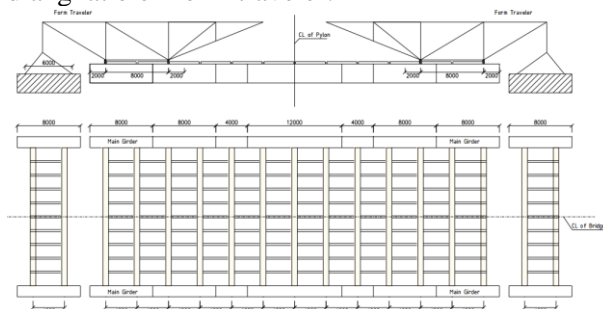
Item	Description		Spesification
1	Model		FT-S
2	Capacity		100t ~ 180t
3	Segmen Length		3.5m ~ 8.0m
4	Deck Width		5m ~ 35m
5	Bridge Curvature Radius		100m-unlimited
6	Bridge Type		Balance Cantilever Box Girder or Cable Stay
7	Launching Mechanism		Hydraulic
8	Formwork Material		Metal Sheet or Plywood Sheet
9	Shape of Bridge Section		Any Shape
10	Production Cycle Time		5 days – 7 days depend on site condition, concreting capacity, concrete design, pier height, reinforcement fabrication method etc.
11	Max. Bridge Slope	Longitudinal	7 %
		Transverse	5 %

Beban form traveler (P_{FT})

$$P_{FT} = 1000\text{kN}$$

2. Beban lantai kendaraan

Direncanakan beban lantai kendaraan dengan segmen per 6m dengan lebar lantai kendaraan 12,4m yang akan diangkat oleh form traveler.



Gambar 5. 36 Segmen deck pada saat pengangkatan (dalam mm)

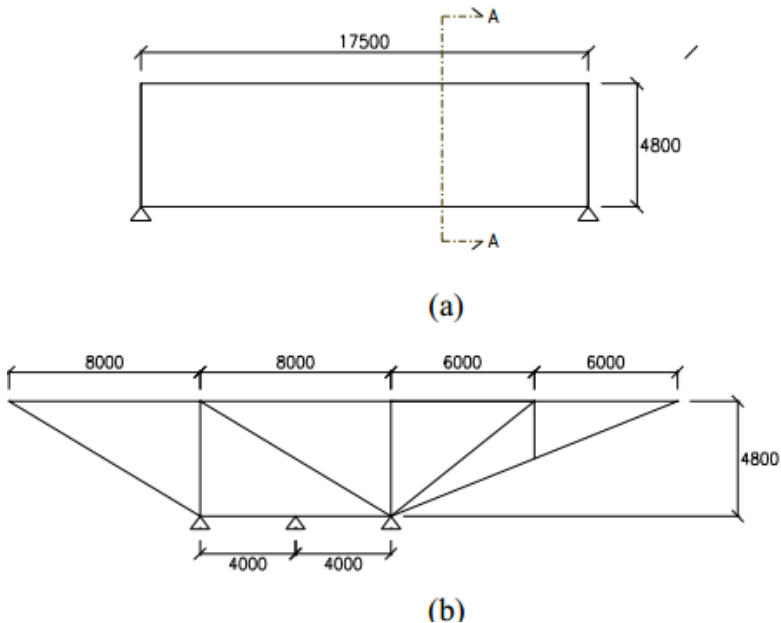
- Gelagar utama (main girder) :
 $w = A \text{ (luas)} \cdot \text{massa jenis} \cdot \text{bentang} \cdot n$
 $= 0.4736 \text{ m}^2 \cdot 7850 \text{ kg/m}^3 \cdot 4 \text{ m} \cdot 2$
 $= 59484 \text{ kg}$
- Balok melintang (floor beam) :
 $w = q \cdot \text{bentang} \cdot n$
 $= 381,8 \text{ kg/m} \cdot 17,5 \text{ m} \cdot 2$
 $= 13363 \text{ kg}$
- Balok memanjang (floor beam) :
 $w = q \cdot \text{bentang} \cdot n$
 $= 64,9 \text{ kg/m} \cdot 4 \text{ m} \cdot 8$
 $= 2076 \text{ kg}$
- Berat total persegmen *deck* :
 $w_{\text{tot}} = 59484 \text{ kg} + 13363 \text{ kg} + 2076 \text{ kg}$
 $= 74923 \text{ Kg}$
 $= 749,23 \text{ kN} \approx 750 \text{ kN}$

Pada saat pelaksanaan *staging analysis* beban *deck* akan dipikul oleh form traveler kemudian akan disalurkan pada jembatan. Konfigurasi pembebanan dapat dilihat pada Tabel 7.12 berikut ini.

Tabel 5. 20 Konfigurasi pembebanan saat staging analysis

Kasus	Konfigurasi Beban
1	DL + ADL + <i>Form Traveler</i>

Berikut ini adalah dimensi form traveler yang digunakan dalam *staging analysis* dapat dilihat pada Gambar 5.37.

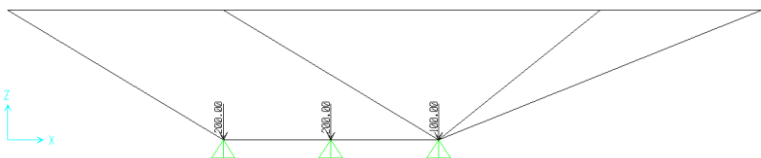


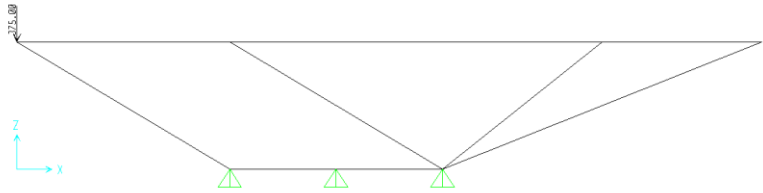
Gambar 5.37 (A) tampak depan, (B) potongan A-A (dalam mm)

Sebelum beban *staging analysis* diinputkan pada program MIDAS CIVIL 2011, terlebih dahulu dianalisa distribusi pembebanan yang akan diterima pada *form traveler*. Dalam analisa akan menggunakan program bantu SAP2000 karena sudah terbiasa menggunakan program tersebut sehingga terkesan lebih mudah dan cepat, berikut ini ilustrasi analisa yang akan dilakukan sesuai pada Gambar 7.23.

Dari perhitungan pembebanan didapatkan

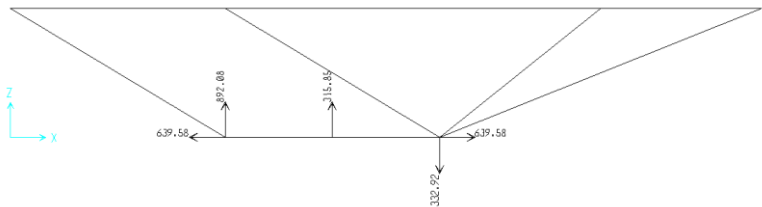
1. Form traveler : 1000 kN
2. Segmen deck : 750 kN
3. Beban total : 1750 kN





Gambar 5. 38 Permodelan dan input beban untuk form traveler

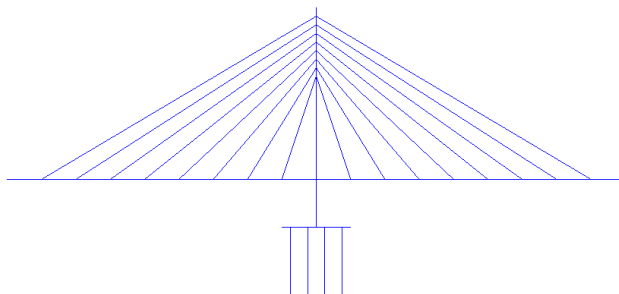
Dalam penginputan beban pada form traveler saat permodelan di SAP2000, berat sendiri profil baja diabaikan sehingga beban dianalisa hanya 1750 kN dari perhitungan sebelumnya yang meliputi beban *deck* dan beban *form traveler* yang sebesar 1000 kN. Untuk pembagian beban dibagi menjadi 2 yaitu tiap sisi *form traveler* menerima 875 kN dimana 50 ton untuk berat sendiri, dan 3,75 ton berat *deck* sehingga total beban yang diterima untuk *form traveler* sebesar 1750 kN. Dari pembebanan tersebut didapat hasil dari analisa SAP2000 untuk *form traveler*. Untuk lebih jelasnya dapat dilihat pada Gambar 5.39.



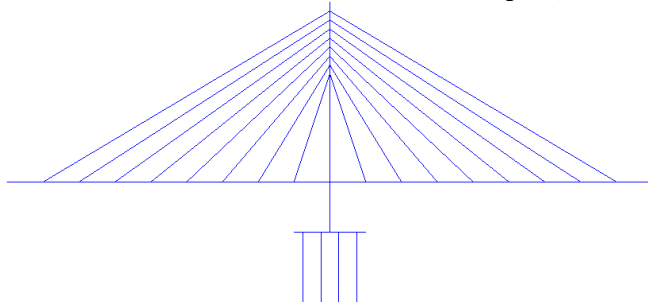
Gambar 5. 39 Hasil analisa reaksi untuk form traveler

5.3.8 Hasil Analisa

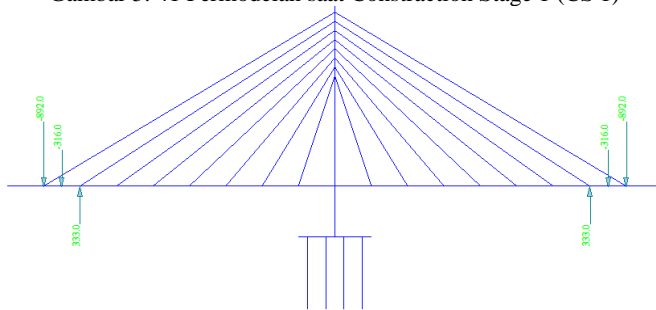
Untuk permodelan *constaction stage* akan dilakukan metode *demolishing procedure* melalui *backward solution* dimana metode dengan pembongkaran dari jembatan sudah terpasang utuh.



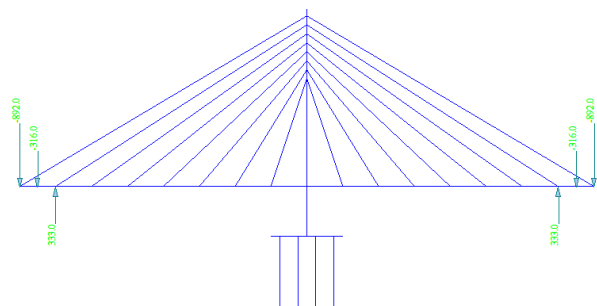
Gambar 5. 40 Permodelan saat Construction Stage 0 (CS 0)



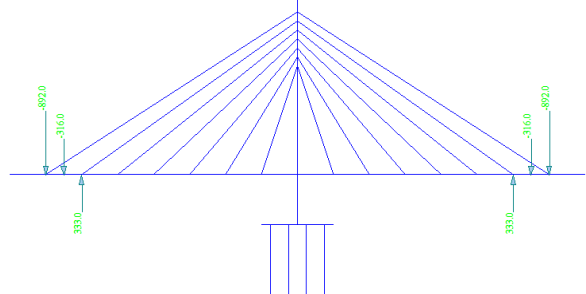
Gambar 5. 41 Permodelan saat Construction Stage 1 (CS 1)



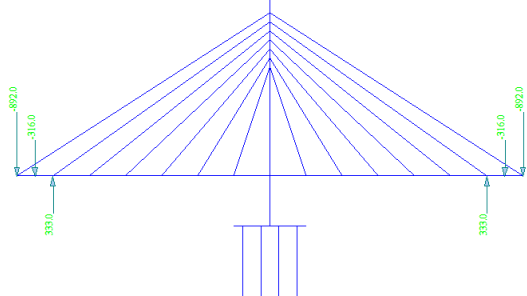
Gambar 5. 42 Permodelan saat Construction Stage 1 (CS 1)



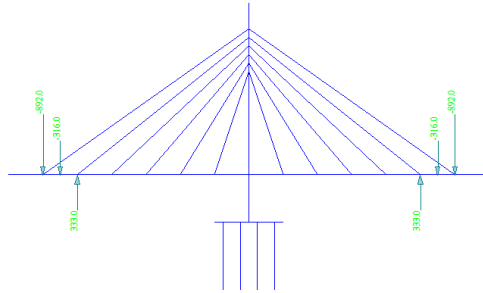
Gambar 5. 43 Permodelan saat Constraction Stage 3 (CS 3)



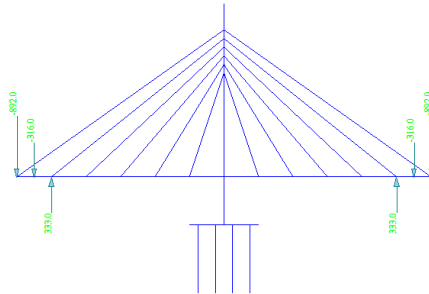
Gambar 5. 44 Permodelan saat Constraction Stage 4 (CS 4)



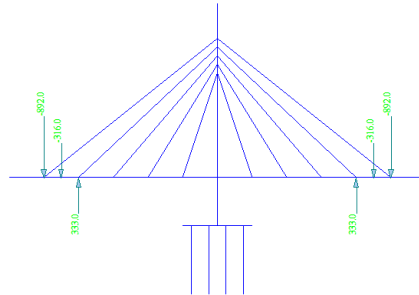
Gambar 5. 45 PermodelansaatConstraction Stage 5 (CS 5)



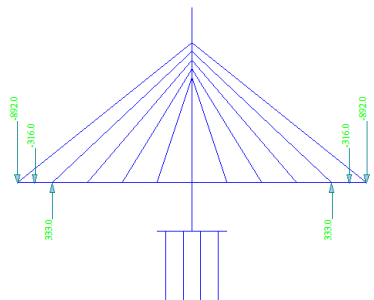
Gambar 5. 46 Permodelan saat Construction Stage 6 (CS 6)



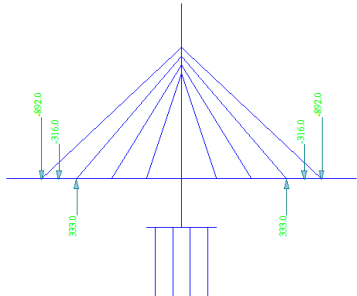
Gambar 5. 47 Permodelan saat Construction Stage 7 (CS 7)



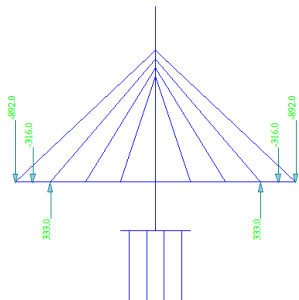
Gambar 5. 48 Permodelan saat Construction Stage8 (CS 8)



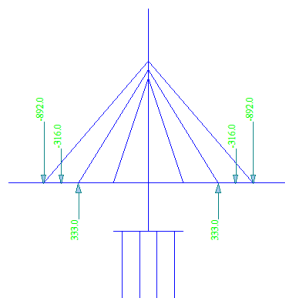
Gambar 5. 49 Permodelan saat Construction Stage 9 (CS 9)



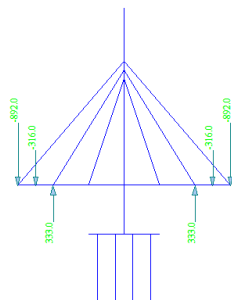
Gambar 5. 50 Permodelan saat Construction Stage 10 (CS 10)



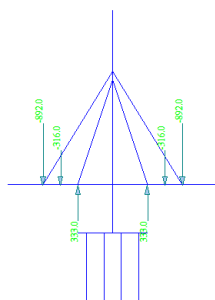
Gambar 5. 51 PermodelansaatConstruction Stage 11 (CS 11)



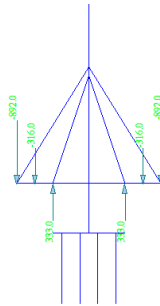
Gambar 5. 52 Permodelan saat Construction Stage 12 (CS 12)



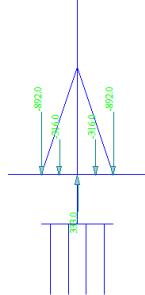
Gambar 5. 53 Permodelan saat Construction Stage 13 (CS 13)



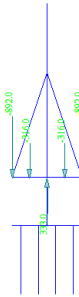
Gambar 5. 54 Permodelan saat Construction Stage 14 (CS 14)



Gambar 5. 55 Permodelan saat Constraction Stage 15 (CS 15)



Gambar 5. 56 Permodelan saat Constraction Stage 16 (CS 16)



Gambar 5. 57 Permodelan saat Constraction Stage 17 (CS 17)

Dari hasil MIDAS CIVIL didapatkan bahwa gaya-gaya yang dihasilkan saat *staging analysis* tidak menentukan, karena gaya yang diperoleh lebih kecil saat beban layan bekerja.

5.3.9 Desain Lead Rubber Bearing

Perletakan yang digunakan sebagai tumpuan dek jembatan adalah tumpuan tipe Lead Rubber Bearing (LRB). LRB bekerja berdasarkan prinsip *base isolation*, dan membatasi energi yang ditransfer dari tanah ke struktur akibat gempa. Material yang digunakan sebagai LRB adalah lapisan *elastomeric* dan perkuatan pelat baja yang divulkanisasi dengan inti timah (*lead*) di bagian tengah, sebagaimana ditunjukkan pada gambar berikut.



Gambar 5. 58 Lead rubber bearing (LRB)

Pada desain jembatan *cable stayed* ini, LRB dimodelkan pada MIDAS Civil dengan properti *General Link* dengan tipe *Lead Rubber Bearing* (LRB). Produk LRB yang digunakan adalah produk Mageba LASTO LRB (Switzerland) dengan spesifikasi sebagai berikut.

Tabel 5. 21 Dimensi Mageba LASTO LRB

LASTO*LRB – $d_{br} = 400\text{mm}$										
D (mm)	t_s (mm)	H_s (mm)	N_{sd} (kN)	N_{st} (kN)	F_1 (kN)	F_2 (kN)	K_1 (kN/mm)	K_{st} (kN/mm)	K_2 (kN/mm)	ξ (%)
500	160	326	3,600	1,250	315	755	1.1	1.89	814	29
600	176	350	5,950	2,150	420	990	1.45	2.49	1,346	28
700	192	374	8,750	3,450	515	1230	1.8	3.09	1,991	28
800	208	398	10,950	5,100	620	1500	2.17	3.73	2,725	26
900	216	410	16,250	6,750	690	1750	2.65	4.38	3,658	26
1000	224	422	18,750	10,100	760	2030	3.16	5.07	4,693	25

Dari hasil pemodelan didapatkan gaya maksimum yang bekerja pada LRB sebagai berikut.

Tabel 0.1 - Gaya maksimum pada LRB

Axial (N)	Shear x (N)	Shear y (N)
4254	1392	971

Kapasitas LRB diberikan sebagai berikut.

Kapasitas aksial,

$$N_{sd} = 10950 \text{ kN} > N_u = 4254 \text{ kN} \dots \dots \dots [\text{memenuhi}]$$

Kapasitas tahanan horizontal,

$$F_2 = 1500 \text{ kN} > V_x = 1392 \text{ kN} \dots \dots \dots [\text{memenuhi}]$$

Berdasarkan analisa dinyatakan bahwa LRB yang digunakan memenuhi persyaratan untuk digunakan dalam desain jembatan *cabl stayed*.

5.4 Gelagar Utama

Data perencanaan gelagar :

BJ 41 → $f_u = 550 \text{ MPa}$

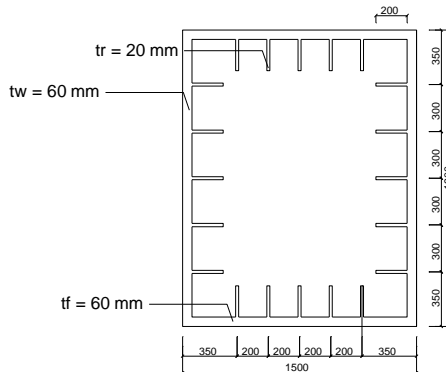
$f_y = 410 \text{ Mpa}$

$H = 1900 \text{ mm}$ $S_{1 \text{ sayap}} = 200 \text{ mm}$

$B = 1500 \text{ mm}$ $S_{2 \text{ badan}} = 300 \text{ mm}$

$t_f = 60 \text{ mm}$ $t_r = 20 \text{ mm}$

$t_w = 60 \text{ mm}$ $h_r = 200 \text{ mm}$



Gambar 5. 59 Dimensi gelagar utama (dalam mm)

$A = 0,4736 \text{ m}^2$ $r_x = 725,379 \text{ mm}$

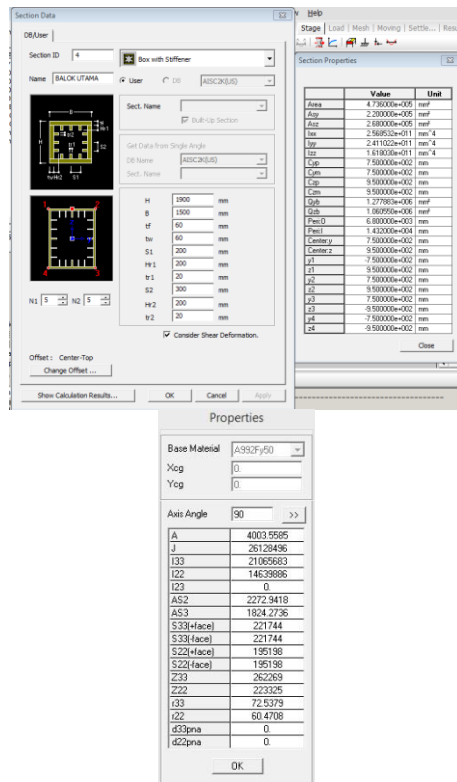
$I_x = 0,2568 \text{ m}^4$ $r_y = 604,708 \text{ mm}$

$I_y = 0,2411 \text{ m}^4$

$Z_x = 262269 \text{ cm}^3$

$Z_y = 223325 \text{ cm}^3$

Berikut ini *section data* dan *section properties* didapat dari program bantu MIDAS CIVIL dan SAP2000 dapat dilihat pada Gambar 8.2



Tabel 5. 22 Gaya dalam pada gelagar utama

Load	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN-m)	Moment-y (kN-m)	Moment-z (kN-m)
Maksimum	1836	314	3570	3789	36463	1201
Minimum	-49602	-314	-4999	-3370	-61047	-1201

5.4.2 Kontrol Kemampuan Penampang

a. Analisa Kuat Aksial

Analisa Batang Tarik (RSNI T-03-2005 ps. 5.1)

$$\begin{aligned}
 N_n &= A_g \cdot f_y \\
 &= 473600 \text{ mm}^2 \cdot 410 \text{ N/mm}^2 \\
 &= 194176000 \text{ N} \\
 &= 194176 \text{ kN}
 \end{aligned}$$

$$\text{Syarat } N_u < \phi N_n$$

$$N_u = 1836 \text{ kN}$$

$$\begin{aligned}
 \phi N_n &= 0,9 \cdot 194176 \text{ kN} \\
 &= 174758 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 N_u &< \phi N_n \\
 1836 \text{ kN} &< 174758 \text{ kN} \dots (\text{OK})
 \end{aligned}$$

Analisa Batang Tekan (RSNI T-03-2005 ps.6.1)

Analisa kelangsingan

$$\lambda_x = \frac{L_{kx}}{i_x} = \frac{4000}{604,7} = 6,61 < 140 \quad \text{OK}$$

$$\lambda_y = \frac{L_{ky}}{i_y} = \frac{4000}{725,37} = 5,51 < 140 \quad \text{OK}$$

$$\lambda_y > \lambda_x$$

$$\lambda_c = \frac{\lambda}{\pi} \sqrt{\frac{f_y}{E}} = \frac{6,61}{\pi} \sqrt{\frac{410}{200000}} = 0,94$$

Untuk nilai $\lambda_c \leq 1,5$

$$N_n = (0,66^{\lambda_c^2}) \cdot A_g \cdot f_y \text{ (RSNI T-03-2005 ps. 6.2)}$$

- Kuat nominal
 $N_n = 134412869 \text{ N}$
- Kontrol (RSNI T-03-2005 ps.6.1)
 $N_u \leq \phi \cdot N_n$
 $49602 \text{ kN} \leq 0,85 \cdot 134412869 \text{ kN}$
 $49602 \text{ kN} \leq 114250 \text{ kN} \quad \text{OK}$

b. Analisa Kuat Geser

Kontrol Geser Arah Y (RSNI T-03-2005 ps.7.8)

$$V_{uy} = 313.89 \text{ kN}$$

$$\begin{aligned} B &= B - 2t_f \\ &= 1500 - 2 \cdot 60 \\ &= 1380 \text{ mm} \end{aligned}$$

$$\begin{aligned} A_f &= 2 \cdot t_f \cdot B \\ &= 2 \cdot 60 \text{ mm} \cdot 1500 \text{ mm} \\ &= 165600 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} b/t_f &= \frac{1380}{60} \\ &= 25 \end{aligned}$$

$$k_v = 5 + \frac{5}{(a_1 / b)^2}$$

$$a_1 = S_{1 \text{ sayap}} = \text{jarak bersih antara pengaku} = 400 \text{ mm}$$

$$\begin{aligned} k_v &= 5 + \frac{5}{\left(\frac{400}{1380}\right)^2} \\ &= 111 \end{aligned}$$

$$1,10 \cdot \sqrt{k_v \cdot E / f_y} = 1,10 \cdot \sqrt{\frac{111 \cdot 200000}{410}} = 255,73$$

$$b/t_f \leq 1,10 \cdot \sqrt{k_v \cdot E / f_y}, \text{ maka } C_v = 1,0$$

$$\begin{aligned} \phi V_n &= \phi \cdot 0,6 \cdot f_y \cdot A_f \cdot C_v \\ &= 0,75 \cdot 0,6 \cdot 410 \text{ N/mm}^2 \cdot 165600 \text{ mm}^2 \cdot 1 \\ &= 30553 \text{ kN} \end{aligned}$$

$$\begin{array}{ll} V_{uy} & < \phi V_{ny} \\ 313,8 \text{ kN} & < 30553 \text{ kN} \dots (\text{OK}) \end{array}$$

Kontrol Geser Arah Z (pada badan)

$$V_{uz} = 3569,72 \text{ kN}$$

$$\begin{aligned} h &= h - 2 \cdot t_f \\ &= 1900 - 2 \cdot 60 \\ &= 1780 \text{ mm} \end{aligned}$$

$$\begin{aligned} A_b &= 2 \cdot t_w \cdot h \\ &= 2 \cdot 60 \text{ mm} \cdot 1780 \text{ mm} \\ &= 213600 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} h/t_w &= \frac{1900}{60} \\ &= 32 \end{aligned}$$

$$k_v = 5 + \frac{5}{(a_1/b)^2}$$

$$a_2 = S_2 \text{ badan} = \text{jarak bersih antara pengaku} = 300 \text{ mm}$$

$$\begin{aligned} k_v &= 5 + \frac{5}{\left(\frac{300}{1780}\right)^2} \\ &= 181 \end{aligned}$$

$$1,10 \cdot \sqrt{k_v \cdot E / f_y} = 1,10 \sqrt{\frac{181 \cdot 200000}{410}} = 327$$

$$h/t_w \leq 1,10 \cdot \sqrt{k_v \cdot E / f_y}, \text{ maka } C_v = 1,0$$

$$\begin{aligned} \phi V_n &= \phi \cdot 0,6 \cdot f_y \cdot A_b \cdot C_v \\ &= 0,75 \cdot 0,6 \cdot 410 \text{ N/mm}^2 \cdot 213600 \text{ mm}^2 \cdot 1 \\ &= 39409 \text{ kN} \end{aligned}$$

$$\begin{array}{rcl} V_{uz} & < & \phi V_{nz} \\ 3569 \text{ kN} & < & 39409 \text{ kN} \dots (\text{OK}) \end{array}$$

c. Analisa Kuat Lentur

Untuk memperoleh nilai modulus plastis penampang box girder 1900.1500.60.60 menggunakan program bantu SAP2000.

Dari analisa menggunakan SAP2000 didapat nilai berikut ini :

$$Z_x = Z_y = 262269000 \text{ mm}^3$$

$$Z_y = Z_z = 223325000 \text{ mm}^3$$

Kontrol Tekuk Lokal (SNI 1729-2015 Tabel B4.1)

$$\begin{aligned} \lambda &= \frac{b}{2.t} & \lambda_p &= \frac{500}{\sqrt{f_y}} \\ &= \frac{1380}{120} & &= \frac{500}{\sqrt{410}} \\ &= 11,5 & &= 24,7 \end{aligned}$$

$\lambda < \lambda_p \dots (\text{OK})$

$$\begin{aligned} \lambda &= \frac{h}{2.t} & \lambda_p &= \frac{1680}{\sqrt{f_y}} \\ &= \frac{1780}{120} & &= \frac{1680}{\sqrt{410}} \\ &= 14,8 & &= 83 \end{aligned}$$

$\lambda < \lambda_p \dots (\text{OK})$

Karena nilai $\lambda < \lambda_p$, maka gelagar utama *box girder* termasuk penampang kompak.

Momen Arah Y (pada sayap)

$$\begin{aligned} M_{ny} &= M_{py} \\ &= Z_y \cdot f_y \\ &= (262269000 \cdot 410) \text{ Nmm} \\ &= 107530 \text{ kNm} \end{aligned}$$

$$\begin{aligned} \phi M_{ny} &= 0,9 \cdot 107530 \text{ kNm} \\ &= 96777 \text{ kNm} \end{aligned}$$

$$\begin{array}{ll} M_{uy} & < \phi M_{ny} \\ 1201,31 \text{ kNm} & < 96777 \text{ kNm} \dots (\text{OK}) \end{array}$$

Momen Arah Z

$$\begin{aligned} M_{nz} &= M_{py} \\ &= Z_z \cdot f_y \\ &= (223325000 \cdot 410) \text{ Nmm} \\ &= 91563,25 \text{ kNm} \end{aligned}$$

$$\begin{aligned} \phi M_{nz} &= 0,9 \cdot 91563,25 \text{ kNm} \\ &= 82407 \text{ kNm} \end{aligned}$$

$$\begin{array}{rcl} M_{uz} & < & \phi M_{nz} \\ 36463 \text{ kN} & < & 82407 \text{ kN} \dots (\text{OK}) \end{array}$$

d. Kombinasi Lentur dan Aksial

Kontrol kemampuan penampang yang berupa simetris ganda dengan interaksi lentur dan aksial. (RSNI T-03-2005 ps.7.16)

$$\frac{P_r}{P_c} = \frac{49602,25}{114250} \frac{8729,54}{79246,55} = 0,43 \geq 0,2$$

maka digunakan rumus 1 sebagai berikut :

$$\frac{N_u}{\phi_c N_n} + \frac{8}{9} \left(\frac{M_{ux}}{\phi_b M_{nx}} + \frac{M_{uy}}{\phi_b M_{ny}} \right) \leq 1,0$$

$$0,782 \leq 1,0$$

5.4.3 Sambungan Gelagar Utama

Sambungan antar gelagar utama berupa sambungan baut dengan pelat baja sebagai penyambung. Sambungan dilakukan pada setiap pertemuan *segmen deck* dimana sambungan tersebut mengelilingi gelagar utama. Beban yang diterima oleh gelagar utama dianggap memikul beban yang sama pada tiap segmen. Berikut gaya maksimum dari gelagar utama :

$$\begin{array}{rcl} N_u & = & 1835,82 \text{ kN} \\ T_u & = & 3788,65 \text{ kNm} \\ V_{uy} & = & 313,89 \text{ kN} \\ V_{uz} & = & 3569,72 \text{ kN} \\ M_{uy} & = & 36463,12 \text{ kNm} \\ M_{uz} & = & 1201,31 \text{ kNm} \end{array}$$

Direncanakan baut Ø36 mm

$$\begin{array}{rcl} f_u & = & 490 \text{ Mpa} \\ A_b & = & 0,25 \cdot \pi \cdot (36 \text{ mm})^2 \\ & = & 1017,9 \text{ mm}^2 \end{array}$$

Lubang perlemahan (d_p)

$$\begin{array}{rcl} d_p & = & 36 \text{ mm} + 1,5 \text{ mm} \\ & = & 37,5 \text{ mm (di bor)} \end{array}$$

Pelat penyambung

$t_p = 30$ mm (dipasang dua bidang geser, luar dan dalam)

Sifat mekanis baja struktural :

$B_J = 55$

$f_u = 550$ Mpa

$f_y = 500$ Mpa

1. Kuat nominal satu (1) baut

a. Kuat geser (V_d)

$\mu = 0,35$ (giling bersih)

$m = 2$ (dua bidang geser)

$$\begin{aligned}\phi V_n &= \phi_f \cdot r_1 \cdot f_u^b \cdot A_b \cdot m \\ &= 0,75 \cdot 0,5 \cdot 490 \cdot 1017,9 \cdot 2 \\ &= 257,25 \text{ kN (menentukan)}\end{aligned}$$

b. Kuat tumpu (R_d)

$$\begin{aligned}\phi R_n &= \phi_f \cdot 2,4 \cdot d_b \cdot t_p \cdot f_u \\ &= 0,75 \cdot 2,4 \cdot 36 \cdot 30 \cdot 550 \\ &= 2138,4 \text{ kN}\end{aligned}$$

Dipakai nilai kuat nominal satu (1) baut

$$\phi V_n = 257,25 \text{ kN}$$

Pelat Badan (samping)

- Syarat jarak antar baut

$$\begin{array}{llll} 3db & \leq & S & \leq 15 \cdot t_p \text{ atau } 200 \text{ mm} \\ 3 (36 \text{ mm}) & \leq & S & \leq 15 (30 \text{ mm}) \text{ atau } 200 \text{ mm} \\ 108 \text{ mm} & \leq & S & \leq 450 \text{ mm atau } 200 \text{ mm} \end{array}$$

Dipakai nilai $S = 110$ mm

- Syarat jarak baut ke tepi pelat

$$\begin{array}{llll} 1,5db & \leq & S & \leq 4 \cdot T_p + 100 \text{ atau } 200 \text{ mm} \\ 1,5(36 \text{ mm}) & \leq & S & \leq 4 (30 \text{ mm}) + 100 \text{ atau } 200 \text{ mm} \\ 54 \text{ mm} & \leq & S & \leq 220 \text{ mm atau } 150 \text{ mm} \end{array}$$

Dipakai nilai $S = 60$ mm

Pelat Sayap (atas)

- Syarat jarak antar baut

$$\begin{aligned} 3db &\leq S \leq 15 \cdot tp \text{ atau } 200 \text{ mm} \\ 3 (36 \text{ mm}) &\leq S \leq 15 (30 \text{ mm}) \text{ atau } 200 \text{ mm} \\ 54 \text{ mm} &\leq S \leq 450 \text{ mm atau } 200 \text{ mm} \end{aligned}$$

Dipakai nilai $S = 110 \text{ mm}$

- Syarat jarak baut ke tepi pelat

$$\begin{aligned} 1,5db &\leq S \leq 4 \cdot Tp + 100 \text{ atau } 200 \text{ mm} \\ 1,5(36 \text{ mm}) &\leq S \leq 4 (30 \text{ mm}) + 100 \text{ atau } 200 \text{ mm} \\ 54 \text{ mm} &\leq S \leq 220 \text{ mm atau } 200 \text{ mm} \end{aligned}$$

Dipakai nilai $S = 60 \text{ mm}$

2. Kebutuhan baut sayap

Untuk menghitung kebutuhan jumlah baut pada sayap *box girder*, maka perlu pembagian gaya dalam yang bekerja pada bagian sayap.

$$\begin{aligned} V_{uy} &= 313,89 \text{ kN} \\ \frac{M_{uy}}{B} &= \frac{36463,12}{1,5} \\ &= 24308,75 \text{ kN} \\ P_{u1} &= P_u \frac{B}{B+H} \\ &= 1835,82 \frac{1,5}{1,5+1,9} \\ &= 809,92 \text{ kN} \\ T_{u1} &= \frac{T_u}{H} \cdot \frac{B}{B+H} \\ &= \frac{3788,65}{1,9} \cdot \frac{1,5}{1,5+1,9} \\ &= 879,71 \text{ kN} \end{aligned}$$

Resultan gaya:

$$\begin{aligned} R_s &= \sqrt{(313,89 + 879,71)^2 + (24308 + 809,92)^2} \\ &= 25147,01 \text{ kN} \\ n_{\text{baut}} &= R_s / V_d = 25147,01 / 257,25 \\ &= 98 \text{ buah} \end{aligned}$$

Maka dipasang pada sisi bawah dan atas sebanyak 100 buah

3. Kebutuhan baut badan

Untuk menghitung kebutuhan jumlah baut pada badan *box girder*, maka perlu pembagian gaya dalam yang bekerja pada bagian badan.

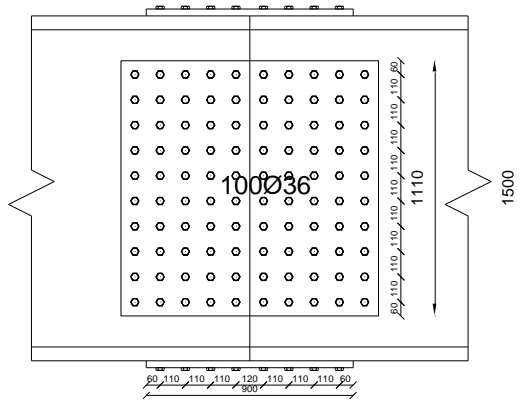
$$\begin{aligned}
 V_{uz} &= 3569,72 \text{ kN} \\
 \frac{M_{uy}}{H} &= \frac{36463,12}{1,9} \\
 &= 19191,12 \text{ kN} \\
 P_{u2} &= P_u \frac{H}{B+H} \\
 &= 1835,82 \frac{1,9}{1,5+1,9} \\
 &= 1025,89 \text{ kN} \\
 T_{u2} &= \frac{T_u}{\frac{B}{B+H}} \cdot \frac{H}{1,9} \\
 &= \frac{3788,65}{1,5} \cdot \frac{1,9}{1,5+1,9} \\
 &= 7998,26 \text{ kN}
 \end{aligned}$$

Resultan gaya:

$$\begin{aligned}
 R_s &= \sqrt{(3569,7 + 7998,2)^2 + (19191,1 \text{ kN} + 1025,8)^2} \\
 &= 23292,61 \text{ kN} \\
 n_{\text{baut}} &= R_s / V_d = 23292,61 / 257,25 \\
 &= 91 \text{ buah}
 \end{aligned}$$

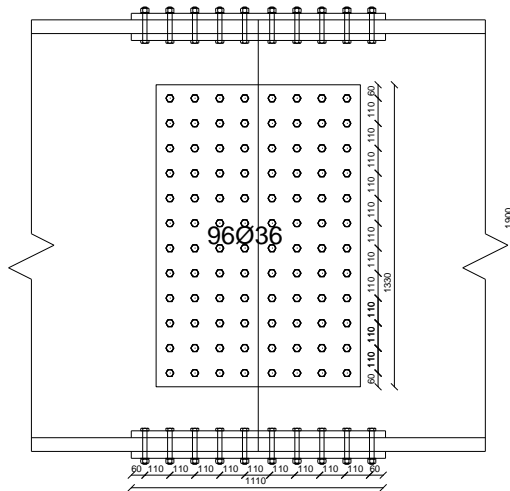
Maka dipasang pada sisi bawah dan atas sebanyak 96 buah

Berikut ini ilustrasi sambungan baut pada gelagar utama pada bagian sayap atau sisi atas dan bawah pada Gambar 8.4.



Gambar 5. 61 Sambungan pada sayap atau sisi atas dan bawah

Berikut ini ilustrasi sambungan baut pada gelagar utama pada bagian badan atau sisi samping pada Gambar 8.5.



Gambar 5. 62 Sambungan pada badan atau sisi samping

Untuk sambungan gelagar utama pada potongan melintang akan terlihat sambungan pada sayap atau sisi atas dan bawah dan sambungan pada badan atau sisi samping dapat dilihat pada Gambar.

$$f_B = \frac{1,1}{2\pi} \left(\frac{g}{v_{maks}} \right)^{1/2}$$

Dimana :

f_B = frekuensi alami lentur (Hz)

g = percepatan gravitasi (m/s^2) = $9,81 m/s^2$

v_{maks} = deformasi statis maksimum akibat berat sendiri (m)
= 0,4m (dari analisa MIDAS CIVIL)

f_T = frekuensi alami torsi (Hz)

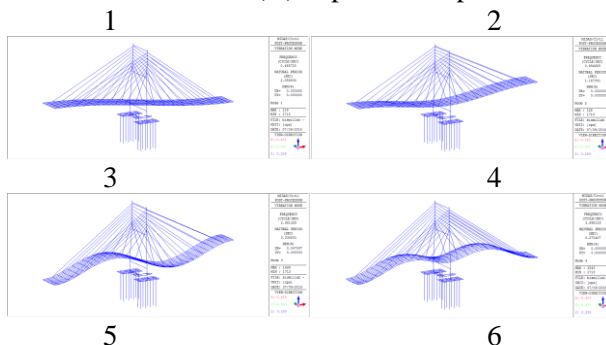
\bar{b} = jarak kabel arah melintang (m) = 8 m

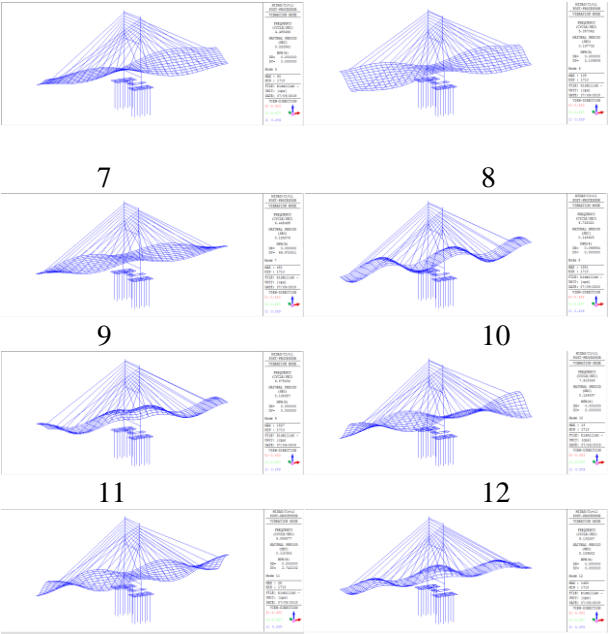
r = jari-jari girasi penampang lantai kendaraan (m) =
8,75m

$$f_B = \frac{1,1}{2\pi} \left(\frac{9,81}{0,4} \right)^{1/2} \quad f_T = \frac{8}{17,5} = 0,46 \text{ Hz}$$

$$f_B = 0,86 \text{ Hz}$$

Akan tetapi didalam program bantu MIDAS CIVIL terdapat nilai frekuensi alami lentur (f_B) dan frekuensi alami torsi (f_T) terhadap struktur dapat dicari dengan menggunakan *modal* tahapan *mode* pada *menu result – vibration mode shapes*. Sebagai berikut perolehan nilai frekuensi alami lentur (f_B) dan frekuensi alami torsi (f_T) dapat dilihat pada Gambar 8.7:





Gambar 5. 64 Mode 1 - 12 frekuensi lentur (fB) dan frekuensi torsi (fT)

Berikut ini adalah rekapitulasi nilai frekuensi lentur dan frekuensi torsi dari analisa menggunakan program bantu MIDAS CIVIL dapat dilihat pada tabel 8.2 :

Tabel 5. 23 Nilai fB dan fT

Mode	Frekuensi Alami	Frequency	Natural Period
		(cycle/sec)	(sec)
1	Frekuensi Lentur (Fb)	0.4857	2.0588
2	Frekuensi Lentur (Fb)	0.8566	1.1673
3	Frekuensi Torsi (ft)	2.9513	0.3388
4	Frekuensi Torsi (ft)	3.6981	0.2704
5	Frekuensi Torsi (ft)	4.4854	0.2229
6	Frekuensi Torsi (ft)	5.0573	0.1977
7	Frekuensi Torsi (ft)	6.4484	0.155
8	Frekuensi Torsi (ft)	6.7283	0.1486
9	Frekuensi Torsi (ft)	6.8782	0.1453
10	Frekuensi Torsi (ft)	7.9153	0.1263
11	Frekuensi Torsi (ft)	9.0592	0.1103
12	Frekuensi Torsi (ft)	9.1322	0.1095

5.5.2 Efek vortex-shedding

Pada kecepatan angin tertentu akan terjadi pusaran angin (*Vortex-Shedding*). Untuk memperoleh kecepatan angin yang mengakibatkan pusaran angin dapat dihitung menggunakan angka *Strouhal* (*S*) dengan persamaan sebagai berikut :

$$S = \frac{f_B \cdot h}{V}$$

Dimana :

S = angka *Strouhal*

V = kecepatan angin yang dihitung berdasarkan angka *Strouhal* (m/s)

h = tinggi lantai kendaraan (m) = 1,9 m

f_B = frekwensi alami lentur (Hz)

Kecepatan angin (*V*) dicari dengan menggunakan persamaan angka *Strouhal*. Dipakai angka *Strouhal* (*S*) = 0,2, tinggi lantai kendaraan (*h*) = 1,8 m

$$\begin{aligned}
 V &= \frac{f_B \cdot h}{S} \\
 &= \frac{1,647}{0,2} \\
 &= 8,2 \text{ m/s}
 \end{aligned}$$

Kemudian dilakukan pengecekan dengan menggunakan persamaan angka Reynold sebagai berikut :

$$Re = \frac{V \cdot B}{\nu}$$

Dimana :

Re = angka *Reynold*, bekisar antara 10^5 sampai 10^7

V = kecepatan angin yang dihitung berdasarkan angka Strouhal

B = lebar lantai kendaraan (17,5 m)

ν = viskositas kinematik udara ($0,15 \text{ cm}^2/\text{dt}$)

$$\begin{aligned}
 Re &= \frac{168,84}{15 \cdot 10^{-4}} \\
 &= 1,13 \cdot 10^6 \quad (10^5 < Re < 10^7)
 \end{aligned}$$

Dengan adanya terpaan angin yang mengakibatkan gaya angkat (*uplift*) maka gaya angkat (*uplift*) tersebut dapat dihitung dengan persamaan sebagai berikut :

$$Fo = \rho \frac{V^2}{2} C \cdot h$$

Dimana :

Fo = gaya angkat

C = koefisien gaya angkat lantai kendaraan

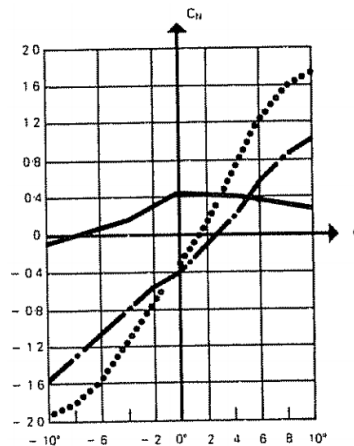
C = koefisien gaya angkat lantai kendaraan

ρ = berat volume udara ($1,3 \text{ kg/m}^3$)

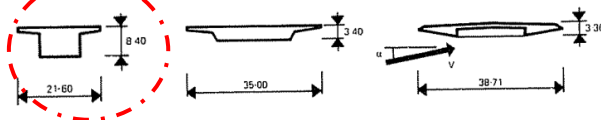
V = kecepatan angin yang dihitung berdasarkan angka Strouhal

h = tinggi lantai kendaraan

Besarnya nilai koefisien C didapat dari grafik pada Gambar 8.8 dan Gambar 8.9:



Gambar 8.8 Koefisien C_N



Gambar 5. 65 Macam-macam penampang deck

Grafik koefisien C_N diatas adalah hasil percobaan dari bentuk penampang lantai kendaraan yang sudah didirikan. Dari beberapa macam bentuk penampang kendaraan, penampang yang ditandai yang cukup mendekati penampang desain. Dengan diambil nilai α diambil 0° dengan nilai koefisien C_N sebesar 0,4.

$$\begin{aligned} F_o &= 1,3 \cdot 10^{\frac{8,2^2}{2}} \cdot 0,4 \cdot 1,9 \\ &= 335,12 \text{ N/m} \end{aligned}$$

Dari gaya ini akan menimbulkan osilasi gelagar yang amplitudonya dapat dihitung sebagai berikut :

$$\hat{v} = \frac{\pi}{\delta} \cdot \frac{F_o}{m} v_{\max}$$

Dimana :

\hat{v} = amplitudo osilasi

δ = penurunan logaritmik (koefisien peredaman)

F_0 = gaya angkat

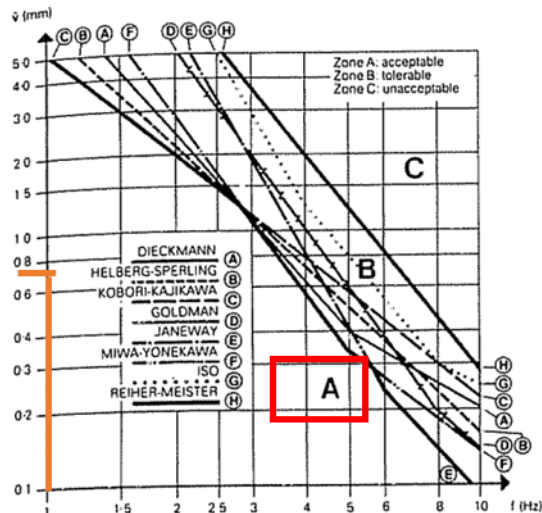
v_{\max} = deformasi statis maksimum karena berat sendiri

m = berat sendiri lantai kendaraan per meter panjang

Dari hasil analisa program MIDAS CIVIL diperoleh nilai v_{\max} akibat berat sendiri sebesar 0,516 m dimana berat sendiri lantai kendaraan adalah 98,47 kN/m. Penurunan logistik (koefisien peredaman) ditentukan sebesar 0,05.

$$\begin{aligned}\hat{v} &= \frac{\pi}{0,05} \frac{335,12}{110,92 \cdot 10^3} \cdot 0,4 \\ &= 0,0759 \text{ m} = 75,93 \text{ mm}\end{aligned}$$

Besarnya amplitudo getaran adalah 7,593 mm dengan deformasi sebesar 0,86 Hz masuk dalam kategori zona A yang diterima (acceptabel). Hal ini dapat dilihat pada grafik pada Gambar 8.10 sebagai berikut ini :

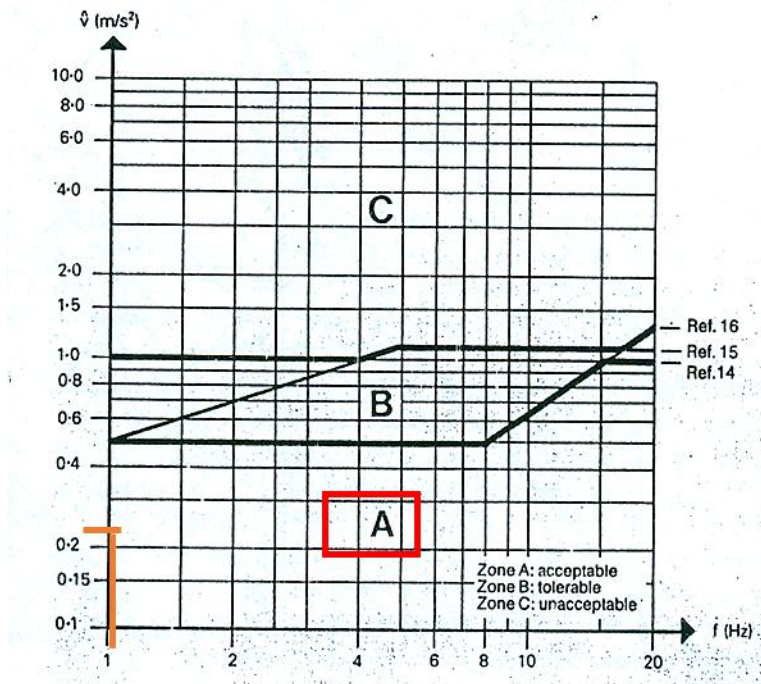


Gambar 5. 66 Klasifikasi efek psikologis berdasarkan amplitudo (Walther, 1999)

Perhitungan tersebut dapat dilanjutkan dengan mencari nilai percepatan getaran yang dihasilkan dari persamaan berikut ini :

$$\begin{aligned}\hat{v} &= 4 \cdot \pi^2 \cdot f^2 \cdot \hat{v} \\ &= 4 \cdot \pi^2 \cdot 0,86^2 \cdot 0,0759 \\ &= 2,25 \text{ m/s}^2\end{aligned}$$

Percepatan getaran diperoleh sebesar 2,25 m/s² dengan frekuensi sebesar 0,86 Hz termasuk zona A yang diterima (acceptabel). Hal ini dapat dilihat dari grafik berikut ini :

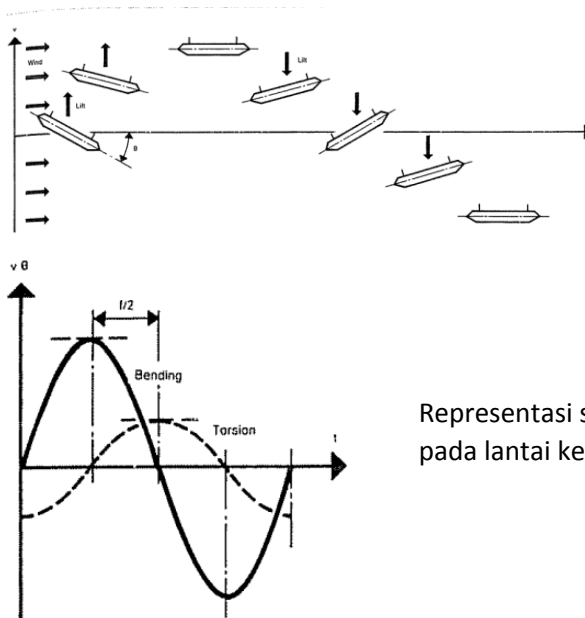


Gambar 5. 67 Klasifikasi efek psikologis berdasarkan percepatan getaran (Walther, 1999)

5.5.3 Efek Flutter (Ayunan)

Kecepatan angin tertentu yang disebut kecepatan kritis yang mengakibatkan suatu efek ayunan. Fenomena efek ayunan

ini berdampak terjadinya ayunan lentur dan ayunan torsi dimana keduanya memiliki perbedaan fase sebesar $\pi/2$. Apabila ayunan lentur dan ayunan torsi terjadi bersamaan meski kecepatan kritis tetap dan akan menyebabkan runtuhnya struktur. Berikut ini ilustrasi pada Gambar 8.12.



Representasi sederhana *flutter* pada lantai kendaraan jembatan

Gambar 5. 68 Efek ayunan dengan beda fase $\pi/2$ (Walther, 1999)

Dari hasil MIDAS CIVIL, di dapatkan efek *flutter* yang dimana menggunakan perbandingan *displacement* dan rotasi dengan periode pada *mode* pertama untuk frekuensi alami lentur (f_B) dan frekuensi alami lentur (f_T).

Untuk mendapatkan kecepatan kritis teoritis, dapat digunakan metode Klöppel, dengan persamaan sebagai berikut

$$\begin{aligned}
 V_{\text{kritis teoritis}} &= 2 \cdot \pi \cdot f_B \cdot b \\
 b &= \frac{1}{2} \text{ lebar lantai kendaraan}
 \end{aligned}$$

Dimana nilai $V_{\text{kritis teori}}$ didapatkan menggunakan grafik pada Gambar 8.13 dan dilihat dari hasil dari tiga (3) besaran berikut ini:

$$(1) \mu = \frac{m}{\pi \cdot \rho \cdot b^2}$$

Dimana :

ρ = Berat volume udara ($1,3 \text{ kg/m}^3$)

m = Berat sendiri lantai kendaraan per meter lari
(98470 N/m)

b = setengah lebar lantai kendaraan ($13,6 \cdot 0,5 = 6,8 \text{ m}$)

$$\mu = \frac{10937,5}{\pi \cdot 1,3 \cdot 8,75^2}$$

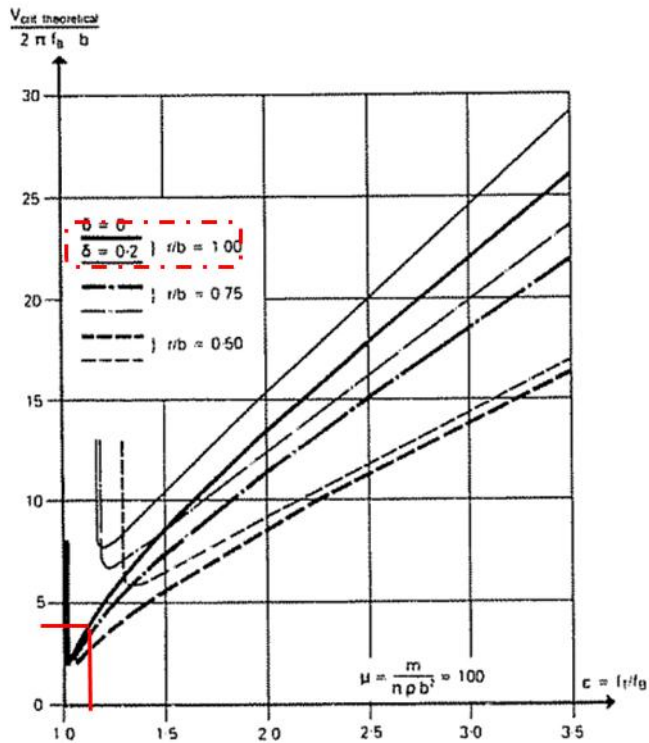
$$= 34,98$$

$$(2) \mathcal{E} = \frac{f_T}{f_B} = \frac{0,396}{0,86} = 0,457$$

$$(3) \frac{r}{b} = \frac{8,75}{8,75} = 1$$

$\delta = 0,05$ (penurunan logaritmatik atau koefisien peredam)

Dari hasil tiga (3) besaran di atas maka akan diplotkan pada Gambar 8.14 akan mendapatkan faktor pengali untuk mnilai kecepatan kritis teoritis.

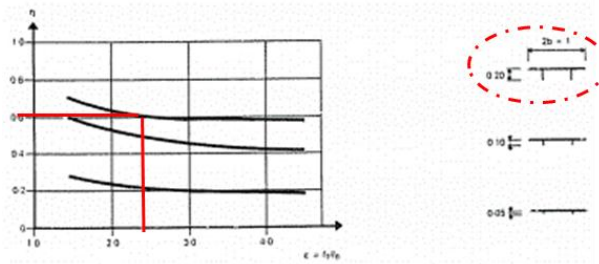


Gambar 5. 69 Kecepatan kritis teoritis untuk flutter (Walther, 1999)

$$\frac{V_{\text{kritis-teoritis}}}{2 \cdot \pi \cdot f_B \cdot b} = 4,9 \dots \text{(dari Gambar 8.13)}$$

$$\begin{aligned} V_{\text{kritis teoritis}} &= 4,9 \cdot (2 \cdot \pi \cdot f_B \cdot b) \\ &= 4,9 \cdot (2 \cdot \pi \cdot 0,86 \cdot 8,75) \\ &= 233,56 \text{ m/s} \end{aligned}$$

Besar kecepatan kritis teoritis ini harus dikoreksi menjadi kecepatan kritis actual, menggunakan grafik berikut, lihat Gambar 5.69.



Gambar 5. 70 Grafik koefisien koreksi (Walther, 1999)

Dari grafik diatas, dengan menyesuaikan bentuk penampang yang paling mendekati didapat nilai $\eta = 0,66$.

$$\begin{aligned} V_{\text{kritis aktual}} &= 0,66 \cdot V_{\text{kritis teoritis}} \\ &= 0,66 \cdot 233,56 \text{ m/s} \\ &= 154 \text{ m/s} \end{aligned}$$

Pada kondisi yang sebenarnya, angin tidak selalu mengenai lantai kendaraan dalam arah horizontal secara sempurna dengan nilai $\alpha = 0^\circ$. Terkadang nilai α dapat berubah sekitar 3° sampai dengan 9° , maka sebagai pembanding dicoba menggunakan nilai α rata-rata sebesar 6° . untuk jenis kendaraan penampang box, perlu koreksi sebesar $1/3$ (Walther, 1999).

$$\begin{aligned} \eta (\alpha = \pm 6^\circ) &= (1/3) \cdot 0,6 \\ &= 0,2 \end{aligned}$$

Sehingga kecepatan kritis aktual :

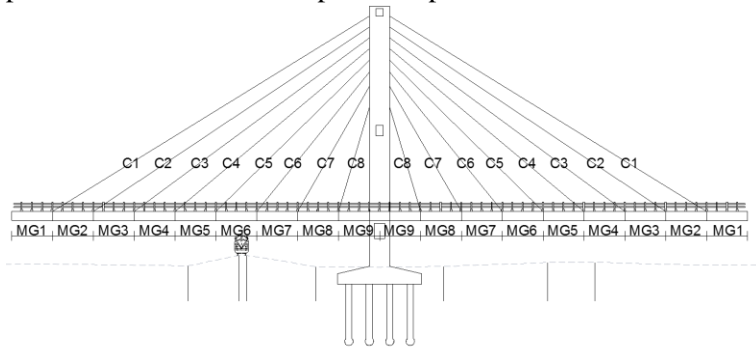
$$\begin{aligned} V_{\text{kritis aktual}} &= 0,2 \cdot 233,56 \text{ m/s} \\ &= 47 \text{ m/s} \end{aligned}$$

$$\begin{aligned} V_{\text{desain}} &< V_{\text{kritis aktual}} \\ 46,36 \text{ m/s} &< 47 \text{ m/s} \dots (\text{OK}) \end{aligned}$$

Hal ini menunjukkan bahwa, apabila pada kondisi nyata dilapangan bertiup angin dengan kecepatan 47 m/s, maka akan muncul efek ayunan (*flutter*). Maka dari itu kecepatan angin di lapangan tidak boleh lebih dari itu, sedangkan pada perencanaan telah didesain besarnya kecepatan angin 46,36 m/s. Sehingga analisa efek ayunan memenuhi. Analisa ini perlu dilanjutkan dengan pembuktian menggunakan model pada terowongan angin, agar diperoleh hasil yang akurat.

5.6 Data Perencanaan Kabel

Seperti pada preliminary desain digunakan jenis kabel paralel *VSL 7-wires strand*. Untuk desain kabel, seperti yang dijelaskan pada RSNI T-03-2005 pasal 12.6 dimana kabel yang menjadi pemikul utama harus dibuat dengan material mutu tinggi dengan kuat tarik minimal 1800 N/mm^2 . maka dipakai kabel dengan tipe ASTM A 416-05 Grade 270. Penamaan dan penomoran untuk kabel dapat dilihat pada Gambar. 9.1.



Gambar 5. 71 Penamaan dan penomoran kabel

Jumlah strand dan luas kabel pada awalnya sudah ditentukan pada bab preliminary desain seperti pada Tabel 9.1. Luas kabel yang didapatkan dari preliminary desain akan dianalisa dengan bantuan program MIDAS CIVIL sehingga akan diperoleh gaya dalam pada kabel. Setelah gaya dalam kabel diperoleh akan didapatkan luas kabel yang sebenarnya dan kemudian diiterasi kembali pada program MIDAS CIVIL untuk memperoleh gaya dalam kabel yang lebih akurat.

Tabel 5. 24 Jumlah strand dan luas kabel pada preliminary desain

No	$S_i = m_i$	α	$\sin \alpha$	$\cos \alpha$	W_{DL}	W_{LL}
		derajat			kN	kN
1	1	22	0.375	0.927	668.791	4493.8
2	2	26	0.438	0.899	668.791	4493.8
3	3	32	0.530	0.848	668.791	4493.8
4	4	45	0.707	0.707	668.791	4493.8
5	5	75	0.966	0.259	668.791	4493.8
No	$N_{gi} = (W_{DL} + W_{LL}) \cdot \cos \alpha$		$\sigma_g = ((\sigma_{gm} \sin 2 \alpha) / 2) - \gamma L$		$A_i = \alpha \cdot N_{gi} / \sigma_g$	$n = A_i / A_s$
	kN		kN/m ²		mm ²	Buah
1	4,786.671		515,670.828		9,282.416	66.30
2	4,640.106		585,125.001		7,930.111	56.64
3	4,378.126		667,547.770		6,558.520	46.85
4	3,650.503		742,845.000		4,914.219	35.10
5	1,336.177		370,845.000		3,603.060	25.74

5.6.1 Gaya Tarik (*Stressing*) Kabel

Seperti yang sudah dijelaskan pada Bab VII dimana kabel akan digaya tarik terlebih dahulu untuk mengetahui gaya tarik awal. Dengan bantuan program bantu MIDAS CIVIL didapatkan gaya tarik dari proses iterasi yang dilakukan secara otomatis oleh program tersebut. Berikut ini adalah hasil dari gaya tarik pada tiap kabel dapat dilihat pada Tabel 9.2.

Tabel 5. 25 Gaya tarik awal (stressing) pada masing-masing kabel

Kabel	Force(kN)
S1	2400
S2	2200
S3	2000
S4	1800
S5	1600
S6	1500
S7	1400
S8	1500

Hasil yang didapat dari hasil iterasi pada tiap kabel yang diperoleh seperti pada Tabel 9.3 sebagai berikut ini :

$$\begin{aligned}
 F_u \text{ kabel} &= 1860 \text{ MPa} \\
 F_u \text{ ijin} &= 0,45 \times 1860 \text{ MPa} \\
 &= 837 \text{ MPa} \\
 &= 0,837 \text{ kN/mm}^2
 \end{aligned}$$

Tabel 5. 26 Kebutuhan luas akibat pretension

Kabel	Fu ijin (kN/mm ²)	Force (kN)	Aps (mm ²)	n ps	Aperlu= P/Fu ijin (mm ²)	n perlu= A/A _s kabel	n pakai	A pakai =n*A _s (mm ²)	Diameter (mm)
S1	0.837	2400	4549	32	2867	20	23	3220	64.03
S2	0.837	2200	4207	30	2628	19	23	3220	64.03
S3	0.837	2000	4015	29	2389	17	23	3220	64.03
S4	0.837	1800	3698	26	2151	15	23	3220	64.03
S5	0.837	1600	3453	25	1912	14	23	3220	64.03
S6	0.837	1500	3152	23	1792	13	23	3220	64.03
S7	0.837	1400	2960	21	1673	12	23	3220	64.03
S8	0.837	1500	3191	23	1792	13	23	3220	64.03

Kemudian diinputkan A_{pakai} ke program bantu MIDAS, akan diperoleh gaya maksimum dari semua kombinasi yang ada. Untuk lebih jelasnya dapat dilihat sebagai berikut :

Tabel 5. 27 Gaya tarik masing-masing kabel

Kabel	Force(kN)
S1	2700
S2	2400
S3	2100
S4	1800
S5	1600
S6	1400
S7	1200
S8	1000

Dari gaya maksimum diatas didapat kebutuhan *strand* dan luas penampang yang sebenarnya. Untuk lebih jelasnya dapat dilihat pada Tabel 5.27.

Tabel 5. 28 Kebutuhan strand dan luas penampang sebenarnya

Kabel	Fu ijin (kN/mm ²)	Force (kN)	A _{ps} (mm ²)	n _{ps}	A _{perlu} = P/Fu ijin (mm ²)	n _{perlu} = A/A _s kabel	n _{pakai}	A _{pakai} =n*A _s	Diameter (mm)
S1	0.837	2700	4549	32	3226	23	31	4340	74.34
S2	0.837	2400	4207	30	2867	20	31	4340	74.34
S3	0.837	2100	4015	29	2509	18	31	4340	74.34
S4	0.837	1800	3698	26	2151	15	22	3080	62.62
S5	0.837	1600	3453	25	1912	14	19	2660	58.20
S6	0.837	1400	3152	23	1673	12	19	2660	58.20
S7	0.837	1200	2960	21	1434	10	19	2660	58.20
S8	0.837	1000	3191	23	1195	9	12	1680	46.25

5.6.2 Analisa Penampang Kabel dengan A_{pakai}

Setelah didapatkan nilai luas penampang, A_{pakai}, dari perhitungan sebelumnya. Nilai A_{pakai} yang telah didapat dimasukkan dalam MIDAS CIVIL untuk memperoleh gaya kabel yang sebenarnya. Berikut hasil yang diperoleh dari analisa program MIDAS CIVIL dapat dilihat dari Tabel 9.4 sebagai berikut ini.

Tabel 5. 29 Hasil analisa gaya tarik dari Apakai

Kabel	Force(kN)
S1	2700
S2	2400
S3	2100
S4	1800
S5	1600
S6	1400
S7	1200
S8	1000

Dari tabel diatas, didapatkan nilai gaya tarik (*stressing*) kabel yang sebenarnya kemudian dicek kembali dengan A_{pakai} yang telah dihitung. Jika kabel dengan menggunakan desain A_{pakai} tersebut mampu menahan gaya kabel, maka Apakai telah

memenuhi gaya yang dibutuhkan. Berikut ini sebagai contoh perhitungan mencari gaya yang mampu diterima oleh kabel.

Kabel C₁ :

$$A_{Spakai} = 1680 \text{ mm}$$

$$P_n = f_{ijin} \cdot A_{Spakai}$$

$$= 0,837 \text{ kN/mm}^2 \cdot 4340 \text{ mm}^2$$

$$= 3633 \text{ kN}$$

$$P = 3500 \text{ kN} \dots (P_n > P \dots \text{OK})$$

Untuk perhitungan kemampuan kabel yang dapat memikul gaya tarik dengan penampang yang digunakan dapat dilihat pada Tabel 9.5 berikut ini.

Tabel 5. 30 Kemampuan kabel dari Aspakai

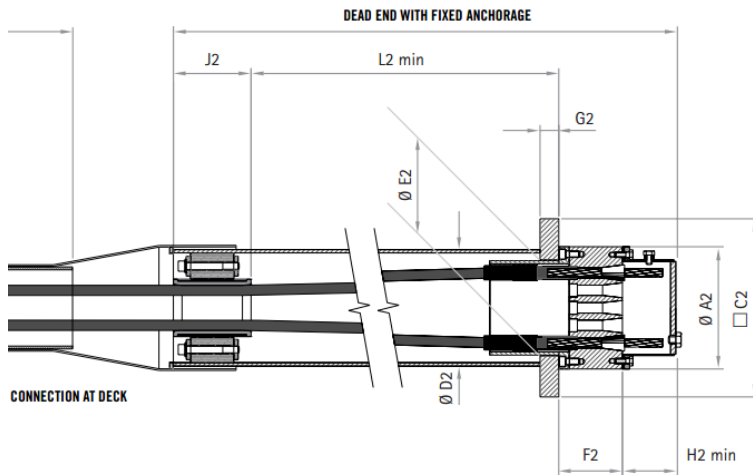
Kabel	A pakai =n*As	Pn (kN)	Force (kN)	Kontrol
S1	4340	3633	2700	OK
S2	4340	3633	2400	OK
S3	4340	3633	2100	OK
S4	3080	2578	1800	OK
S5	2660	2226	1600	OK
S6	2660	2226	1400	OK
S7	2660	2226	1200	OK
S8	1680	1406	1000	OK

Dari hasil di atas dapat disimpulkan bahwa luas penampang dan jumlah *strand* yang dibutuhkan mampu menahan gaya tarik yang terjadi.

5.6.3 Analisa Anker pada gelagar

Desain anker dipasang sesuai dengan jumlah kebutuhan *strand* yang direncanakan. Pada perhitungan anker terdapat kontrol yang perlu diperhitungkan antara lain adalah cek kontrol tegangan plat baja akibat gaya tarik dari kabel. Berikut

ini spesifikasi jumlah strand dan dimensi anker pada Gambar 5.71.



Dead End										Stay Pipe	
TENDON UNIT	ØA2 mm	C2 mm	ØD2 mm	ØE2 mm	F2 mm	G2 mm	H2 min mm	J2 mm	L2min mm	TENDON UNIT	ØA3 mm
6-12	185	260	177.8/4.5	150	105	35	105	160	900	6-12	125/4.9
6-19	230	335	219.1/6.3	190	120	50	105	180	1,200	6-19	140/5.4
6-22	250	355	219.1/6.3	205	120	50	105	210	1,350	6-22	160/6.2
6-31	280	415	244.5/6.3	230	145	60	105	210	1,550	6-31	160/6.2
6-37	300	455	273/6.3	255	170	70	105	210	1,750	6-37	180/5.6
6-43	340	505	323.9/7.1	285	175	75	105	210	2,000	6-43	200/6.2
6-55	380	550	323.9/7.1	310	195	75	105	260	2,050	6-55	200/6.2
6-61	380	585	355.6/8	330	215	85	105	260	2,250	6-61	225/7.0
6-73	430	650	406.4/8.8	370	215	95	120	290	2,450	6-73	250/7.8
6-85	430	685	406.4/8.8	370	245	110	120	290	2,600	6-85	250/7.8
6-91	480	730	457/10	420	255	110	120	320	2,800	6-91	280/8.7
6-109	495	775	457/10	420	265	120	120	320	3,000	6-109	315/9.8
6-127	550	845	508/11	475	315	130	120	340	3,350	6-127	315/9.8

Gambar 5. 72 Spesifikasi teknis dan karakteristik anker

Berikut ini contoh perhitungan anker yang digunakan pada S₄ dengan gaya yang paling besar sebagai berikut.

Data perencanaan :

Tabel 5. 31 Data anker yang dipakai

Anker	Strand	Strand	Strand	Strand
	12	19	22	31
ØA2	185	230	250	280
ØC2	260	335	355	415

Perhitungan untuk kabel S1 dengan strand 31

$$P = 3500 \text{ kN}$$

$$\text{ØA2} = 280 \text{ mm}$$

$$C1 = 415 \text{ mm}$$

$$A_{p'} = C1^2$$

$$= 172225 \text{ mm}^2$$

$$A_p = A_{p'} - 0,25 \cdot \pi \cdot (\text{ØA2})^2$$

$$= 172225 - 0,25 \cdot \pi \cdot (280)^2$$

$$= 172005 \text{ mm}^2$$

Tegangan ijin pelat baja pada saat pemberian gaya tarik :

Pelat baja BJ41

$$f_y = 250 \text{ MPa}$$

$$f_u = 410 \text{ MPa}$$

$$f_{yp} = 0,8 \cdot f_y \sqrt{\frac{A_{p'}}{A_p}} - 0,2$$

$$= 0,8 \cdot 250 \sqrt{\frac{172225}{172005}} - 0,2$$

$$= 179 \text{ MPa}$$

Tegangan di bawah pelat anker :

$$f_t = \frac{P}{A_p}$$

$$= \frac{3500 \cdot 1000}{172005} = 20,35 \text{ MPa}$$

$$f_t < f_{yp}$$

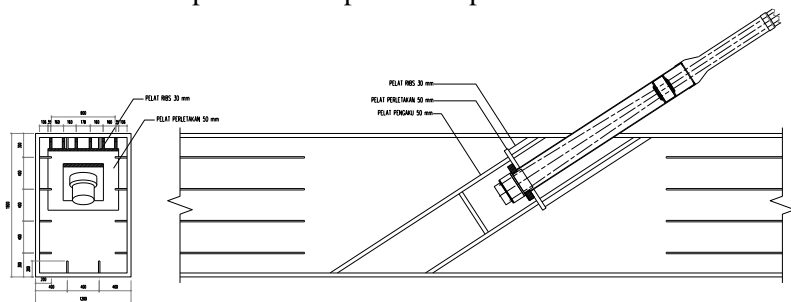
$$20,35 \text{ kN} < 179 \text{ kN} \dots (\text{OK})$$

Untuk perhitungan kontrol tagangan anker yang lain dapat dilihat pada Tabel 9.6 berikut ini.

Tabel 5. 32 Perhitungan angker keseluruhan

Kabel	Anker	Force (kN)	Ap' (mm ²)	Ap (mm ²)	fyp (Mpa)	ft (Mpa)	Kontrol
S1	31	2700	172225	172005	179	15.70	OK
S2	31	2400	172225	172005	179	13.95	OK
S3	31	2100	172225	172005	179	12.21	OK
S4	22	1800	126025	125829	179	14.31	OK
S5	19	1600	112225	112044	179	14.28	OK
S6	19	1400	112225	112044	179	12.50	OK
S7	19	1200	112225	112044	179	10.71	OK
S8	12	1000	67600	67455	179	14.82	OK

Untuk kontrol anker yang menerima gaya tarik (*stressing*) berikut ilustrasi plat anker dapat dilihat pada Gambar 9.3



Gambar 5. 73 Pelat anker dan dimensi

1. Untuk 31 strand, di kontrol S₁ sebagai gaya yang terbesar mewakili anker lain
 - a. Kuat lentur pelat sayap
 SNI03-1729-2002, ps. 8.10.2

$$\phi R_b = \phi \cdot 6,25 \cdot t_f^2 \cdot f_y$$

$$= 0,85 \cdot 6,25 \cdot (50\text{mm})^2 \cdot 250\text{N/mm}^2$$

$$= 3320312,5 \text{ N}$$

$$= 3320,3 \text{ kN}$$
 - b. Kuat leleh pelat badan
 SNI 03-1729-2002, ps. 8.10.3

$$\phi R_b = \phi \cdot (5k + N) \cdot t_w \cdot f_y$$

dimana :

k = tebal pelat sayap ditambah jari-jari peralihan
 N = dimensi arah longitudinal pelat perletakan
 atau tumpuan, minimal sebesar k .

$$\phi R_b = 0,85 \cdot (5 \cdot 50 + 415) \text{ mm} \cdot 50 \text{ mm} \cdot 250 \text{ N/mm}^2 \\ = 7066 \text{ kN}$$

- c. Kuat tekuk dukung pelat badan
 SNI03-1729-2002, ps. 8.10.4 (8.10-4.c)

$$\phi R_b = 0,39 \cdot t_w^2 \left[1 + \left\{ 4 \left(\frac{N}{d} \right) - 0,2 \right\} \left(\frac{t_w}{t_f} \right)^{1,5} \right] \sqrt{\frac{E \cdot f_y \cdot t_f}{t_w}} \\ = 0,85 \cdot 0,39 \cdot 50^2 \left[1 + \left\{ 4 \left(\frac{505}{1800} \right) - 0,2 \right\} \left(\frac{50}{50} \right)^{1,5} \right] \sqrt{\frac{2 \cdot 10^5 \cdot 250 \cdot 50}{50}} \\ = 5229 \text{ kN}$$

- d. Kuat tekuk lentur pelat badan
 SNI03-1729-2002, ps. 8.10.6

$$\phi R_b = \frac{12,08 t_w^3}{h} \sqrt{E f_y} \\ = 0,85 \cdot \frac{12,08 \cdot 50^3}{1800} \sqrt{2 \cdot 10^5 \cdot 250} \\ = 5042 \text{ kN}$$

Dari perhitungan di atas dipakai nilai ϕR_b yang terkecil sebesar 3320,313 kN.

Pada setiap satu anker ditumpu oleh 2 plat sehingga gaya yang diterima pada satu anker adalah

$$P = 0,5 \cdot 3500 \text{ kN} \\ = 1750 \text{ kN}$$

$$P < \phi R_b \\ 1750 \text{ kN} < 3320,313 \text{ kN}$$

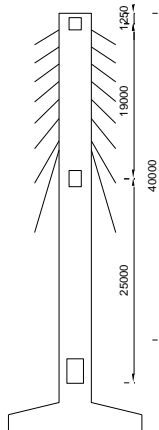
Dari perhitungan diatas maka didapat bahwa $P < \phi R_b$, maka pelat mampu menahan beban yang terjadi.

5.7 Analisa Struktur Pylon

Struktur *pylon* berfungsi untuk memikul beban pada lantai kendaraan yang disalurkan oleh kabel, kemudian menyalurkan beban tersebut ke *pilecap* dan pondasi. Material yang digunakan untuk struktur *pylon* adalah material beton bertulang dengan mutu tinggi. Mutu tinggi digunakan untuk memenuhi kapasitas *pylon* yang harus mencukupi dalam memikul beban-beban yang bekerja. Peraturan yang digunakan dalam mendesain struktur *pylon* adalah RSNI T 12 2004 tentang Struktur Beton untuk Jembatan.

5.7.1 Gaya Dalam pada Pylon

Gaya dalam pada *pylon* didapatkan dari hasil pemodelan menggunakan program bantu MIDAS Civil. Kemudian gaya tersebut dikoreksi dengan penambahan gaya akibat momen sekunder yang dianalisa berdasarkan kelangsingan struktur *pylon*.



Gambar 5. 74 Potongan memanjang struktur pylon

Penampang pada *pylon* yang akan dilakukan analisa penulangan adalah pada daerah di bawah angkur kabel dan pada daerah angkur kabel. Penampang tersebut ditunjukkan pada gambar 9.1 berikut.

Gaya dalam hasil pemodelan yang digunakan untuk mendesain tulangan pylon diberikan sebagai berikut.

Gaya dalam desain *section A-A*:

a) Untuk Analisa Sumbu Kuat

Tabel 5. 33 Gaya dalam maksimum-X1 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
51	R214Ekstrim1kiriEx	I[42]	-29273.2	-269.44
51	R214Ekstrim1kiriEx	J[41]	-34145.4	145.21
Shear-z (kN)	Torsion (kN·m)	Moment-x (kN·m)	Moment-y (kN·m)	
-1450.16	-1597.65	15391.42	-1625.08	
-1450.16	-1597.65	54059.67	1119.51	

b) Untuk Analisa Sumbu Lemah

Tabel 5. 34 Gaya dalam maksimum-Y1 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
53	R219Ekstrim1fullEy	I[41]	-35662.82	552.15
53	R219Ekstrim1fullEy	J[40]	-37217.78	552.15
Shear-z (kN)	Torsion (kN·m)	Moment-x (kN·m)	Moment-y (kN·m)	
26.87	0.01	953.14	3869.72	
26.87	0.01	1151.54	1122.87	

Gaya dalam desain *section B-B*:

a) Untuk Analisa Sumbu Kuat

Tabel 5. 35 Gaya dalam maksimum-X2 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
2498	R214Ekstrim1kiriEx	I[448]	2507.44	-121.38
2498	R214Ekstrim1kiriEx	J[41]	2507.44	-121.38
Shear-z (kN)	Torsion (kN·m)	Moment-X (kN·m)	Moment-Y (kN·m)	
413.05	0	-508.15	2329.53	
918.41	0	-2626.14	2776.94	

b) Untuk Analisa Sumbu Lemah

Tabel 5. 36 Gaya dalam maksimum-Y2 untuk pylon

Shear-z (kN)	Torsion (kN·m)	Moment-X (kN·m)	Moment-Y (kN·m)	
-861.6	0	2890.56	41.18	
1859.58	0	608.08	41.18	
Elem	Load	Part	Axial (kN)	Shear-y (kN)
2499	R218Ekstrim1lajurEy	I[449]	2510.8	0
2499	R218Ekstrim1lajurEy	J[448]	2510.8	0

Gaya dalam desain *section C-C*:

a) Untuk Analisa Sumbu Kuat

Tabel 5. 37 Gaya dalam maksimum-X2 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
48	R214Ekstrim1kiriEx	I[4]	-11327.43	324.59
48	R214Ekstrim1kiriEx	J[5]	-11647.75	324.59
Shear-z (kN)	Torsion (kN·m)	Moment-X (kN·m)	Moment-Y (kN·m)	
295.96	-194.82	692.56	-184.68	
295.96	-194.82	366.82	-832.43	

b) Untuk Analisa Sumbu Lemah

Tabel 5. 38 Gaya dalam maksimum-Y2 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
52	R219Ekstrim1fullEy	I[43]	-775.54	685.71
52	R219Ekstrim1fullEy	J[2]	-895.66	685.71
Shear-z (kN)	Torsion (kN·m)	Moment-X (kN·m)	Moment-Y (kN·m)	
0	4.39	0	2687.85	
0	4.39	0	2173.57	

Gaya dalam desain *section D-D*:

a) Untuk Analisa Sumbu Kuat

Tabel 5. 39 Gaya dalam maksimum-X2 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
87	R3,515EkstrimlajurEy	I[63]	-657.44	0
87	R3,515EkstrimlajurEy	J[43]	-657.44	0

Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)	Moment-z (kN·m)
-552.42	0	-1704.3	8.37
613.8	0	-2089.25	8.37

b) Untuk Analisa Sumbu Lemah

Tabel 5. 40 Gaya dalam maksimum-Y2 untuk pylon

Elem	Load	Part	Axial (kN)	Shear-y (kN)
85	R214Ekstrim1kiriEx	I[64]	-3166.81	0
85	R214Ekstrim1kiriEx	J[42]	-3166.81	0
Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)	Moment-z (kN·m)	
-550.21	0	-1498.35	291.86	
616.01	0	-1498.35	291.86	

5.7.2 Analisa Kelangsingan dan Momen Sekunder

5.7.2.1 Spesifikasi Material dan Dimensi Pylon

Spesifikasi material beton dan tulangan diberikan sebagai berikut:

Kuat tekan beton, f_c' = 40 MPa

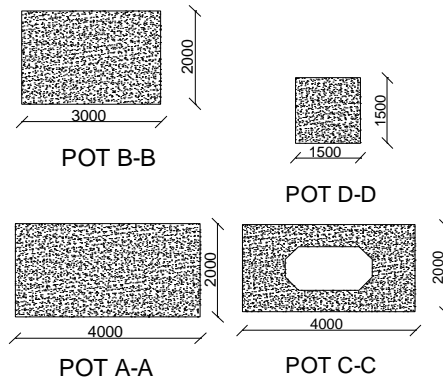
Modulus elastisitas beton =

$$E_c = 4700 \sqrt{f_c'} = 4700 \sqrt{40} = 29725 \text{ MPa}$$

Kuat leleh baja, f_y = 390 MPa

Modulus elastisitas baja, E_s = 200000 MPa

Dimensi pylon dibagi menjadi 4, yaitu pada *section A-A*, *section B-B*, *section C-C* dan *section D-D* sebagai berikut:



Gambar 5. 75 Penampang pylon

5.7.2.2 Kelangsingan Pylon

Faktor panjang tekuk ditentukan berdasarkan asumsi bahwa *pylon* merupakan struktur jepit-bebas, sehingga nilai $K = 2,2$ berdasarkan RSNI T 12 2004 gambar 5.7-1.

Tinggi *pylon*, $H = 45250$ mm

Faktor reduksi momen inersia = 0,7 (Pasal 5.7.4.2)

Section-A-A:

$$A_{g1} = 8000000 \text{ mm}^2$$

$$I_{x1} = 5126919000000 \text{ mm}^4$$

$$I_{y1} = 746669000000 \text{ mm}^4$$

$$r_x = \sqrt{\frac{I_x}{A_g}} = \sqrt{\frac{5126919000000}{8000000}} = 801 \text{ mm}$$

$$r_y = \sqrt{\frac{I_y}{A_g}} = \sqrt{\frac{746669000000}{8000000}} = 97 \text{ mm}$$

Kelangsingan terhadap sumbu x:

$$\frac{KH}{r_x} = \frac{2,2 \times 25000}{801} = 68,7 > 22 \text{[kolom langsing]}$$

Kelangsingan terhadap sumbu y:

$$\frac{KH}{r_y} = \frac{2,2 \times 25000}{97} = 569,3 > 22 \text{[kolom langsing]}$$

Section-B-B:

Luas penampang,

$$Ag_2 = 6000000 \text{ mm}^2$$

$$Ix_2 = 3286710000000 \text{ mm}^4$$

$$Iy_2 = 3150000000000 \text{ mm}^4$$

$$rx = \sqrt{\frac{Ix}{Ag}} = \sqrt{\frac{3286710000000}{6000000}} = 740 \text{ mm}$$

$$ry = \sqrt{\frac{Iy}{Ag}} = \sqrt{\frac{3150000000000}{6000000}} = 725 \text{ mm}$$

Kelangsingan terhadap sumbu x:

$$\frac{KH}{rx} = \frac{2,2 \times 27000}{801} = 80,3 > 22 \dots\dots\dots[\text{kolom langsing}]$$

Kelangsingan terhadap sumbu y:

$$\frac{KH}{ry} = \frac{2,2 \times 27000}{97} = 82 > 22 \dots\dots\dots[\text{kolom langsing}]$$

Section-C-C:

Luas penampang,

$$Ag_3 = 6180000 \text{ mm}^2$$

$$Ix_3 = 3780000000000 \text{ mm}^4$$

$$Iy_3 = 71022000000 \text{ mm}^4$$

$$rx = \sqrt{\frac{Ix}{Ag}} = \sqrt{\frac{3780000000000}{6180000}} = 782 \text{ mm}$$

$$ry = \sqrt{\frac{Iy}{Ag}} = \sqrt{\frac{71022000000}{6180000}} = 107 \text{ mm}$$

Kelangsingan terhadap sumbu x:

$$\frac{KH}{rx} = \frac{2,2 \times 20250}{782} = 57 > 22 \dots\dots\dots[\text{kolom langsing}]$$

Kelangsingan terhadap sumbu y:

$$\frac{KH}{ry} = \frac{2,2 \times 20250}{107} = 518,2 > 22 \dots\dots\dots[\text{kolom langsing}]$$

Section-D-D:

Luas penampang,

$$Ag_4 = 2250000 \text{ mm}^2$$

$$Ix_4 = 498337000000 \text{ mm}^4$$

$$Iy_4 = 295260000000 \text{ mm}^4$$

$$r_x = \sqrt{\frac{I_x}{A_g}} = \sqrt{\frac{498337000000}{2250000}} = 471 \text{ mm}$$

$$r_y = \sqrt{\frac{I_y}{A_g}} = \sqrt{\frac{295260000000}{2250000}} = 362 \text{ mm}$$

Kelangsingan terhadap sumbu x:

$$\frac{KH}{r_x} = \frac{2,2 \times 22000}{471} = 102,8 > 22 \dots\dots\dots [\text{kolom langsing}]$$

Kelangsingan terhadap sumbu y:

$$\frac{KH}{r_y} = \frac{2,2 \times 22000}{362} = 133,6 > 22 \dots\dots\dots [\text{kolom langsing}]$$

5.7.2.3 Perbesaran Momen

Perbesaran momen dihitung pada masing-masing *section* sesuai dengan Pasal 5.7.6 RSNI T 12 2004.

a) Pada Section-A-A

Analisa pada sumbu kuat (sumbu x):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma P_u = 34145400 \text{ N}$$

$$V_u = 269440 \text{ N}$$

$$\Delta_0 = 9.316 \text{ mm}$$

$$l = 25000 \text{ mm}$$

$$Q = \frac{\Sigma P_u \Delta_0}{V_u l} = \frac{34145400 \times 9,316}{269440 \times 25000} = 0,034 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M_1 = 54059670000 \text{ N-mm}$$

$$M_2 = 15391420000 \text{ N-mm}$$

$$C_m = 0,6 + 0,4 \frac{M_1}{M_2} \geq 0,4 = 0,6 + 0,4 \frac{54059670000}{15391420000} = 0,713 > 0,4$$

$$P_D = 33941790 \text{ N (beban mati terfaktor)}$$

$$\beta_d = \frac{P_D}{P_u} = \frac{33941790}{34145400} = 0,994$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 7324170000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 89253125000000}{1 + 0,994}$$

$$= 43673002924935500 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 43673002924935500}{(2,2 \times 25000)^2} = 142490996 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75P_c}}}{1 - \frac{0,713}{\frac{34145400}{0,75 \times 142490996}}} = 1,04 < 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2\min} = Pu (15 + 0,03h)$$

$$= 4609629000,4 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2$$

$$= 1,04 \cdot 4609629000$$

$$= 16146729226 \text{ N-mm}$$

$$= 16146,72923 \text{ kN-m}$$

Analisa pada sumbu lemah (sumbu y):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 37217780 \text{ N}$$

$$Vu = 552150 \text{ N}$$

$$\Delta_0 = 9,316 \text{ mm}$$

$$l = 25000 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{37217780 \times 9,316}{552150 \times 25000} = 0,034 < 0,05 \text{ [tak}$$

bergoyang]}

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 1122870000 \text{ N-mm}$$

$$M2 = 3869720000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{1122870000}{3869720000} = 0,716 >$$

$$0,4$$

$$P_D = 33941790 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{33941790}{37217780} = 0,912$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 106667000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 106667000000}{1 + 0,994} = 663338302377778 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 663338302377778}{(2,2 \times 25000)^2} = 2164260 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75P_c}}}{1 - \frac{0,716}{\frac{37217780}{0,75 \times 2164260}}} = 0,033 < 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2min} = Pu (15 + 0,03h) = 5024400300 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$\begin{aligned} M_c &= \delta_{ns} M2 \\ &= 1 \cdot 5024400300 \\ &= 5024400300 \text{ N-mm} \\ &= 5024 \text{ kN-m} \end{aligned}$$

b) Pada Section-B-B

Analisa pada sumbu kuat (sumbu x):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 2507440 \text{ N}$$

$$Vu = 918410 \text{ N}$$

$$\Delta_0 = 7.95 \text{ mm}$$

$$l = 27000 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{2507440 \times 7.95}{918410 \times 27000} = 0,008 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 2626140000 \text{ N-mm}$$

$$M2 = 508150000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{2626140000}{508150000} = 0,68 > 0,4$$

$$P_D = 2510800 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{2510800}{2507440} = 1,0013$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 4695300000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 469530000000}{1 + 1,0013} = 27895253530877000 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 27895253530877000}{(2,2 \times 27000)^2} = 78029203 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{P_u}{0,75 P_c}}}{1 - \frac{0,68}{\frac{2507440}{0,75 \times 78029203}}} = 0,71 < 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2min} = P_u (15 + 0,03h) = 338504400 \text{ N-mm} < M_2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M_2 = 1 \cdot 508150000 = 508150000 \text{ N-mm} = 508 \text{ kN-m}$$

Analisa pada sumbu lemah (sumbu y):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\begin{aligned} \Sigma P_u &= 2510800 \text{ N} \\ V_u &= 1859580 \text{ N} \\ \Delta_0 &= 7,95 \text{ mm} \\ l &= 27000 \text{ mm} \\ Q &= \frac{\Sigma P_u \Delta_0}{V_u l} = \frac{2510800 \times 7,95}{1859580 \times 27000} = 0,0004 < 0,05 \text{ [tak} \end{aligned}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$\begin{aligned} M_1 &= 41180000 \text{ N-mm} \\ M_2 &= 41180000 \text{ N-mm} \\ C_m &= 0,6 + 0,4 \frac{M_1}{M_2} \geq 0,4 = 0,6 + 0,4 \frac{41180000}{41180000} = 1,4 > 0,4 \\ P_D &= 2510800 \text{ N (beban mati terfaktor)} \\ \beta_d &= \frac{P_D}{P_u} = \frac{2510800}{2510800} = 1 \end{aligned}$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 4500000000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 450000000000}{1 + 1}$$

$$= 26752869005024500 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 26752869005024500}{(2,2 \times 27000)^2} = 74833700 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75 P_c}}}{1 - \frac{1,4}{\frac{2510800}{0,75 \times 74833700}}} = 1,46 > 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2min} = Pu (15 + 0,03h)$$

$$= 338958000 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2$$

$$= 1,47 \cdot 338958000$$

$$= 496764267 \text{ N-mm}$$

$$= 497 \text{ kN-m}$$

c) Pada Section-C-C

Analisa pada sumbu kuat (sumbu x):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 11647750 \text{ N}$$

$$Vu = 324590 \text{ N}$$

$$\Delta_0 = 10.58 \text{ mm}$$

$$l = 20250 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{11647750 \times 10.58}{324590 \times 20250} = 0,019 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 366820000 \text{ N-mm}$$

$$M2 = 692560000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{366820000}{692560000} = 0,81 > 0,4$$

$$P_D = 12590430 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{12590430}{11647750} = 1,08$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 5400000000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 5400000000000}{1 + 1,08}$$

$$= 30854864180720600 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 30854864180720600}{(2,2 \times 20250)^2} = 153436247 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{Pu}}{1 - \frac{0,75 P_c}{Pu}} = \frac{\frac{0,81}{11647750}}{1 - \frac{0,75 \times 153436247}{11647750}} = 0,903 < 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2\min} = Pu (15 + 0,03h) \\ = 1572446250 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2 \\ = 1 \cdot 1572446250 \\ = 1572446250 \text{ N-mm} \\ = 1572 \text{ kN-m}$$

Analisa pada sumbu lemah (sumbu y):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 895660 \text{ N}$$

$$Vu = 685710 \text{ N}$$

$$\Delta_0 = 10.58 \text{ mm}$$

$$l = 20250 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{895660 \times 10.58}{685710 \times 20250} = 0,0007 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 2173570000 \text{ N-mm}$$

$$M2 = 2687850000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{2173570000}{2687850000} = 0,92 > 0,4$$

$$P_D = 12590430 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{12590430}{895660} = 14,06$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 101460000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 10146000000}{1 + 14,3}$$

$$= 80119794817309 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 80119794817309}{(2,2 \times 20250)^2} = 398423 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75P_c}}}{1 - \frac{0,92}{\frac{895660}{0,75 \times 398423}}} = 0,46 > 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2min} = Pu (15 + 0,03h) \\ = 120914100 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2 \\ = 1 \cdot 2687850000 \\ = 2687850000 \text{ N-mm} \\ = 2688 \text{ kN-m}$$

d) Pada Section-D-D

Analisa pada sumbu kuat (sumbu x):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 657440 \text{ N}$$

$$Vu = 613800 \text{ N}$$

$$\Delta_0 = 10.59 \text{ mm}$$

$$l = 22000 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{657440 \times 10.59}{613800 \times 22000} = 0,00052 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 2089250000 \text{ N-mm}$$

$$M2 = 1704300000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{2089250000}{1704300000} = 1,09 > 0,4$$

$$P_D = 2693290 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{2693290}{657440} = 4,1$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 711910000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 711910000000}{1 + 1,08}$$

$$= 1660847007055560 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 1660847007055560}{(2,2 \times 22000)^2} = 6997431 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75P_c}}}{1 - \frac{1,09}{0,75 \times 6997431}} = 1,25 > 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2min} = Pu (15 + 0,03h) \\ = 88754400 \text{ N-mm} < M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2 \\ = 1,25 \cdot 1704300000 \\ = 2124410500 \text{ N-mm} \\ = 2124 \text{ kN-m}$$

Analisa pada sumbu lemah (sumbu y):

Pemeriksaan kolom bergoyang atau tak bergoyang,

$$\Sigma Pu = 3166810 \text{ N}$$

$$Vu = 616010 \text{ N}$$

$$\Delta_0 = 10.59 \text{ mm}$$

$$l = 22000 \text{ mm}$$

$$Q = \frac{\Sigma Pu \Delta_0}{Vu l} = \frac{3166810 \times 10.59}{616010 \times 22000} = 0,0025 < 0,05 \text{ [tak}$$

bergoyang]

Karena section-1 merupakan kolom tak bergoyang maka perbesaran momen dihitung sebagai berikut.

$$M1 = 291860000 \text{ N-mm}$$

$$M2 = 291860000 \text{ N-mm}$$

$$Cm = 0,6 + 0,4 \frac{M1}{M2} \geq 0,4 = 0,6 + 0,4 \frac{291860000}{291860000} = 1 > 0,4$$

$$P_D = 2693290 \text{ N (beban mati terfaktor)}$$

$$\beta d = \frac{P_D}{Pu} = \frac{2693290}{3166810} = 0,85$$

Nilai kekaun (EI) dihitung berdasarkan Pasal 5.7.6.3

RSNI T 12-2004 sebagai berikut.

$$I_g = I_{x1} / 0,7 = 421800000000 \text{ mm}^4$$

$$EI = \frac{0,4 E_c I_g}{1 + \beta d} = \frac{0,4 \times 29725 \times 42180000000}{1 + 0,85} = 2710262779358370 \text{ N-mm}^2$$

$$P_c = \frac{\pi^2 EI}{(Klu)^2} = \frac{\pi^2 2710262779358370}{(2,2 \times 22000)^2} = 11418799 \text{ N}$$

$$\delta_{ns} = \frac{\frac{Cm}{1 - \frac{Pu}{0,75Pc}}}{1 - \frac{1}{\frac{3166810}{0,75 \times 11418799}}} = 1,58 > 1$$

Nilai M2 diambil tidak boleh kurang dari nilai berikut.

$$M_{2\min} = Pu (15 + 0,03h) = 427519350 \text{ N-mm} > M2$$

Maka dipakai nilai M2 dari hasil pemodelan.

$$M_c = \delta_{ns} M2 = 1,58 \cdot 427519350 = 678362415 \text{ N-mm} = 678 \text{ kN-m}$$

5.7.3 Penulangan Pylon

Penulangan longitudinal *pylon* dilakukan menggunakan program bantu spColumn. Pada spColumn dimodelkan penampang *pylon*.

Sedangkan penulangan sengkang transversal dihitung secara manual berdasarkan SNI T 12 2004 Pasal 5.2.

5.7.3.1 Perhitungan Tulangan Longitudinal

Gaya yang diintupkan dalam perhitungan spColumn adalah gaya yang telah dihitung berdasarkan perbesaran momen sesuai perhitungan di atas. Rekapitulasi gaya hasil perhitungan perbesaran momen diberikan pada tabel berikut.

Tabel 0.2 - Rekapitulasi gaya pada pylon

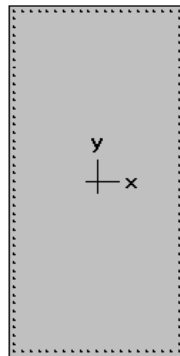
SECTION	Aksial (kN)	Momen X (kNm)	Momen Y (kNm)
A-A	34145	16147	5024
B-B	2507	1572	497
C-C	11648	1572	2688
D-D	657	2124	678

Direncanakan tulangan longitudinal D57 dan tulangan transversal D16 dengan kuat tarik baja $f_y = 420$ MPa. Secara lengkap diberikan sebagai berikut:

Kuat tekan beton, f_c'	= 40 MPa
Modulus elastisitas beton, E_c	= 29725 MPa
Kuat tarik baja, f_y	= 390 MPa
Modulus elastisitas baja, E_s	= 200000 MPa
Tulangan longitudinal, D_L	= 32 mm dan 25 mm
Tulangan transversal, D_T	= 16 mm
Clear cover	= 50 mm

a) Penulangan Section-A-A

Pemodelan ditunjukkan dalam gambar berikut.



2000 × 4000 mm
1.27% reinf.

Gambar 5. 76 Pemodelan penulangan section-A-A

Hasil penulangan:

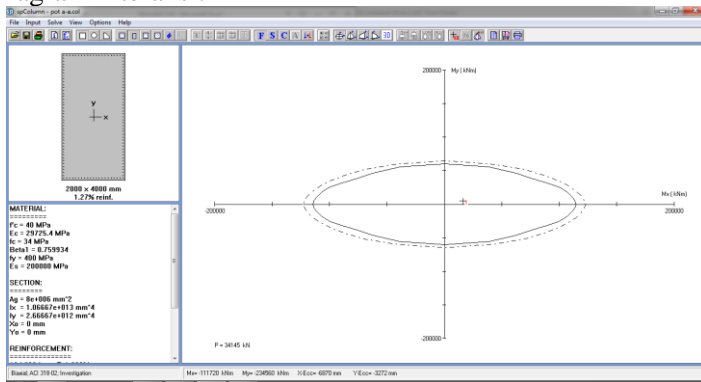
Material:

f_c'	= 40 MPa
E_c	= 29725 MPa
f_y	= 400 MPa
E_s	= 200000 MPa

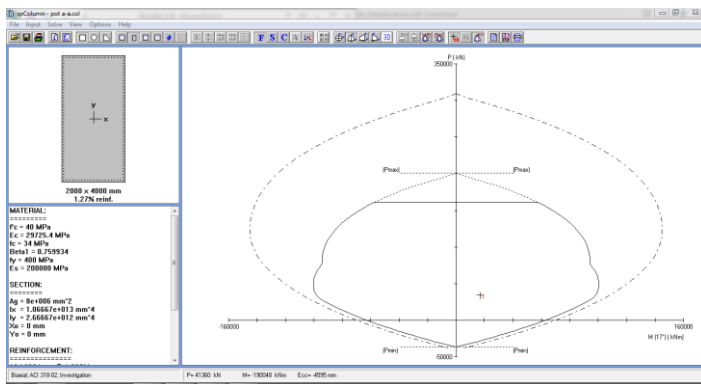
Reinforcement:

Diameter tul	= 32 mm
Rasio, ρ	= 1,84%
Jumlah tul	= 124 buah

Diagram interaksi:



Gambar 5. 77 Diagram interaksi Mx-My analisa spColumn

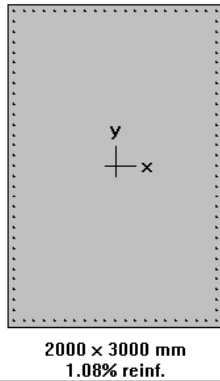


Gambar 5. 78 Diagram interaksi P-M analisa spColumn

Dari kedua diagram interaksi di atas dapat dilihat bahwa gaya dalam maksimum yang bekerja pada *pylon* masih di dalam zona aman sehingga disimpulkan bahwa penampang dengan penulangan longitudinal yang telah didesain memenuhi persyaratan.

b) Section-B-B

Pemodelan pada section-2 ditunjukan dalam gambar berikut.



Gambar 5. 79 Pemodelan penulangan section-2

Hasil penulangan:

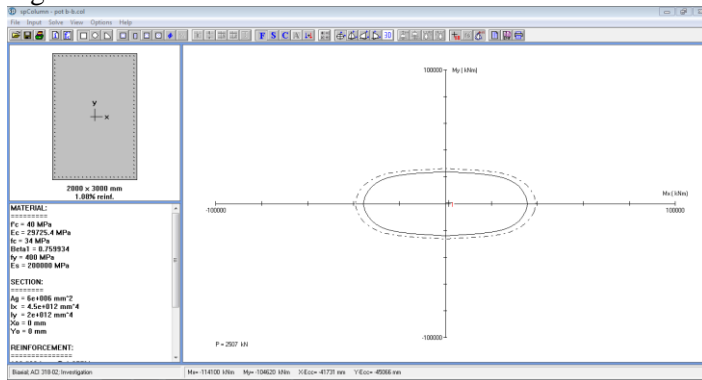
Material:

f_c' = 40 MPa
 E_c = 29725 MPa
 f_y = 400 MPa
 E_s = 200000 MPa

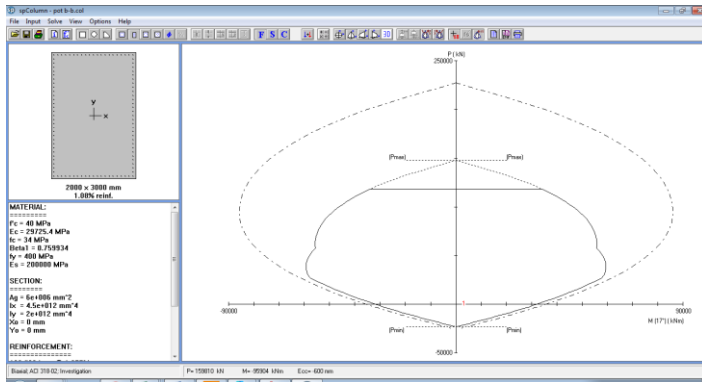
Reinforcement:

Diameter tul = 29 mm
 Rasio, ρ = 1,08%
 Jumlah tul = 100 buah

Diagram interaksi:



Gambar 5. 80 Diagram interaksi Mx-My analisa spColumn

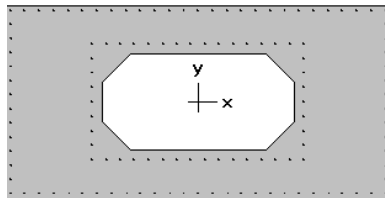


Gambar 5. 81 Diagram interaksi P-M analisa spColumn

Dari kedua diagram interaksi di atas dapat dilihat bahwa gaya dalam maksimum yang bekerja pada *pylon* masih di dalam zona aman sehingga disimpulkan bahwa penampang dengan penulangan longitudinal yang telah didesain memenuhi persyaratan.

c) Section-C-C

Pemodelan pada section-2 ditunjukkan dalam gambar berikut.



4000 × 2000 mm
1.61% reinf.

Gambar 5. 82 Pemodelan penulangan section-2

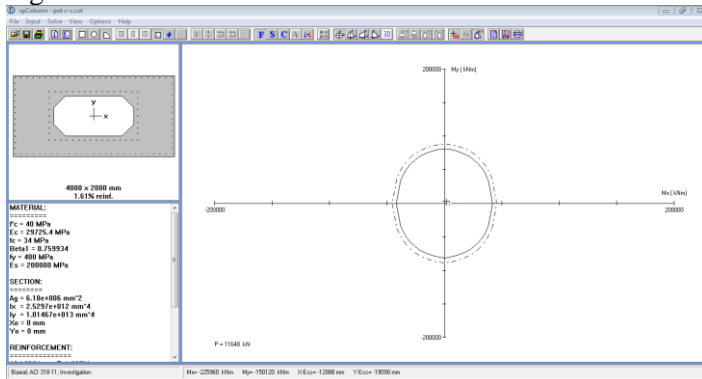
Hasil penulangan:

Material:

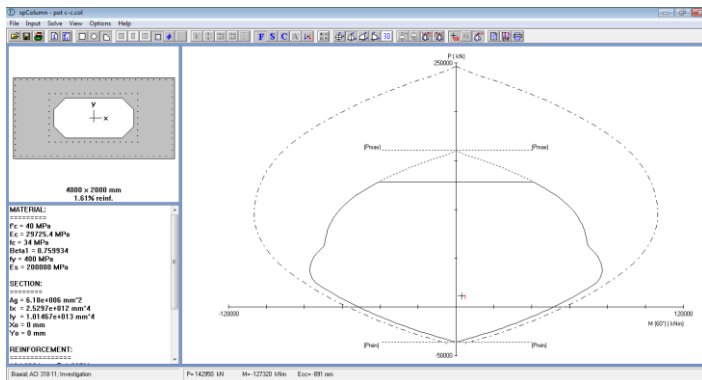
$f_c' = 40 \text{ MPa}$
 $E_c = 29725 \text{ MPa}$
 $f_y = 400 \text{ MPa}$
 $E_s = 200000 \text{ MPa}$

Reinforcement:

Diameter tul = 32 mm
 Rasio, $\rho = 1,61\%$
 Jumlah tulangan = 124 buah

Diagram interaksi:

Gambar 5. 83 Diagram interaksi Mx-My analisa spColumn



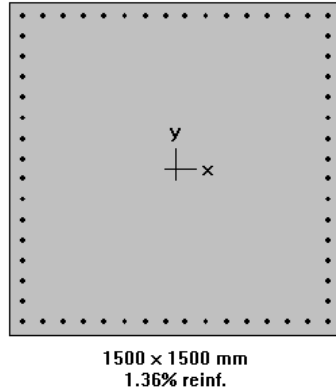
Gambar 5. 84 Diagram interaksi P-M analisa spColumn

Dari kedua diagram interaksi di atas dapat dilihat bahwa gaya dalam maksimum yang bekerja pada *pylon* masih

di dalam zona aman sehingga disimpulkan bahwa penampang dengan penulangan longitudinal yang telah didesain memenuhi persyaratan.

d) Section-D-D

Pemodelan pada section-2 ditunjukkan dalam gambar berikut.



Gambar 5. 85 Pemodelan penulangan section-2

Hasil penulangan:

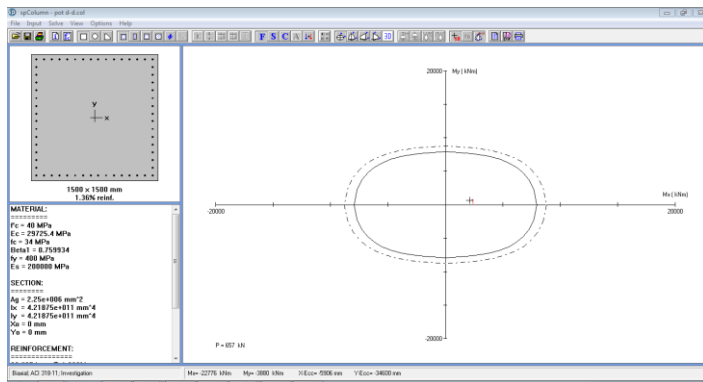
Material:

f_c' = 40 MPa
 E_c = 29725 MPa
 f_y = 400 MPa
 E_s = 200000 MPa

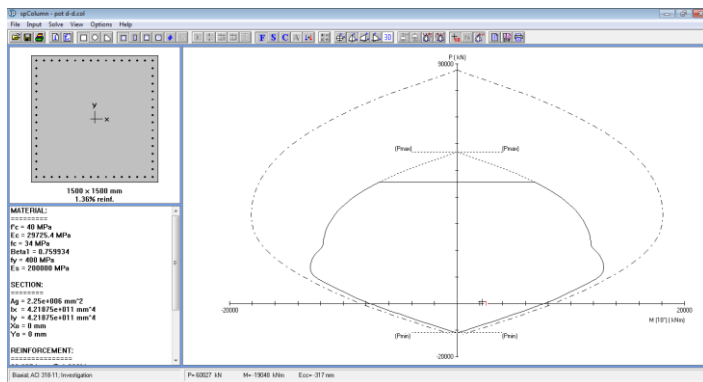
Reinforcement:

Diameter tul = 25 mm
 Rasio, ρ = 1,36%
 Jumlah tul = 60 buah

Diagram interaksi:



Gambar 5. 86 Diagram interaksi Mx-My analisa spColumn



Gambar 5. 87 Diagram interaksi P-M analisa spColumn

Dari kedua diagram interaksi di atas dapat dilihat bahwa gaya dalam maksimum yang bekerja pada *pylon* masih di dalam zona aman sehingga disimpulkan bahwa penampang dengan penulangan longitudinal yang telah didesain memenuhi persyaratan.

Kontrol jarak antar tulangan:

	DIPAKAI (mm)	SYARAT (mm)	
A-A	59.80	50	OK
B-B	64.91	50	OK
C-C	114.22	50	OK
D-D	66.24	50	OK

Kontrol rasio tulangan:

Berdasarkan SNI T 12 2004 Pasal 5.7.8.1 disyaratkan rasio tulangan longitudinal kolom tidak boleh kurang dari 0,01 Ag dan tidak boleh melebihi 0,08 Ag.

Rasio tulangan berdasarkan perhitungan dapat dilihat dalam tabel berikut:

	DIPAKAI (mm)	SYARAT (mm)		
A-A	1.27%	1.00%	8.00%	[memenuhi]
B-B	1.08%	1.00%	8.00%	[memenuhi]
C-C	1.61%	1.00%	8.00%	[memenuhi]
D-D	1.36%	1.00%	8.00%	[memenuhi]

5.3.2 Perhitungan Tulangan Transversal

5.3.2.1 Perhitungan Tulangan

a) Section-A-A

Gaya geser maksimum desain:

$$\begin{aligned}
 V_y &= 269440 \text{ N} & f_c' &= 40 \text{ MPa} \\
 V_x &= 552150 \text{ N} & f_y &= 400 \text{ MPa} \\
 T_u &= 1816.92 \cdot 10^6 \text{ N-mm} & D_T &= 16 \text{ mm} \\
 N_u &= 38435350 \text{ N}
 \end{aligned}$$

Tinjauan geser pada sumbu kuat (arah x):

$$V_c = \left(1 + \frac{N_u}{14A_g}\right) \frac{\sqrt{f_c'}}{6} b_w d$$

$$A_g = 8000000 \text{ mm}^2$$

$$b_w = 2000 \text{ mm}$$

$$\begin{aligned}
 d &= h - 2 \cdot \text{clearcover} - D_T - 0,5D_L \\
 &= 4000 - 50 - 16 - (0,5 \cdot 32) \\
 &= 3918 \text{ mm}
 \end{aligned}$$

$$\begin{aligned}
 V_c &= \left(1 + \frac{38435350}{14 \times 8000000}\right) \frac{\sqrt{40}}{6} \cdot 2000 \cdot 3918 \\
 &= 11094431 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 \phi V_c &= 0,7 \cdot V_c \\
 &= 0,7 \cdot 11094431 \\
 &= 7766102 \text{ N}
 \end{aligned}$$

$$0,5 \phi V_c = 0,5 \cdot 7766102 = 3883051 \text{ N}$$

$$V_u = V_y = 269440 \text{ N} < 0,5 \phi V_c = 3883051 \text{ N}$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 3 kaki,

$$A_v = 3 \cdot 0,25 \pi D^2 = 3 \cdot 0,25 \cdot \pi \cdot 16^2 = 603 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 603 \times 400}{2000} = 362 \text{ mm}$$

Tinjauan geser pada sumbu lemah (arah y):

$$V_c = \left(1 + \frac{N_u}{14 A_g} \right) \frac{\sqrt{f_c}}{6} b_w d$$

$$A_g = 8000000 \text{ mm}^2$$

$$b_w = 4000 \text{ mm}$$

$$d = b - 2 \text{clearcover} - D_T - 0,5 D_L$$

$$= 2000 - (50) - 16 - (0,5 \cdot 32)$$

$$= 1934 \text{ mm}$$

$$V_c = \left(1 + \frac{38435350}{14 \times 8000000} \right) \frac{\sqrt{40}}{6} \cdot 4000 \cdot 1934$$

$$= 8154504 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 8154504$$

$$= 5708153 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 5708153 = 2854076 \text{ N}$$

$$V_u = V_x = 552150 \text{ N} < 0,5 \phi V_c = 2854076 \text{ N}$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 5 kaki,

$$A_v = 5 \cdot 0,25 \pi D^2 = 5 \cdot 0,25 \cdot \pi \cdot 16^2 = 1005 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 1005 \times 400}{4000} = 302 \text{ mm}$$

Tinjauan terhadap torsi:

Pengaruh torsi boleh diabaikan bila persamaan berikut terpenuhi.

$$T_u < \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$$

$$T_u = 1816.92.10^6 \text{ N-mm}$$

$$A_{cp} = 2000 \cdot 4000 = 8000000 \text{ mm}^2$$

$$p_{cp} = 2 \cdot (2000 + 4000) = 12000 \text{ mm}$$

$$\begin{aligned} \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right) &= 0,75 \cdot 0,083 \cdot \sqrt{40} \left(\frac{8000000^2}{12000} \right) \\ &= 2099752366 \text{ N-mm} > T_u \end{aligned}$$

Persamaan di atas memenuhi dengan $T_u <$

$0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$ sehingga pengaruh torsi dapat diabaikan.

b) Section-B-B

Gaya geser maksimum desain:

$$V_y = 918410 \text{ N}$$

$$f'c' = 40 \text{ MPa}$$

$$V_x = 1859580 \text{ N}$$

$$f_y = 400 \text{ MPa}$$

$$T_u = 0 \text{ N-mm}$$

$$D_T = 16 \text{ mm}$$

$$N_u = 2646040 \text{ N}$$

Tinjauan geser pada sumbu kuat (arah x):

$$V_c = \left(1 + \frac{N_u}{14A_g} \right) \frac{\sqrt{f'c'}}{6} b_w d$$

$$A_g = 6000000 \text{ mm}^2$$

$$b_w = 2000 \text{ mm}$$

$$d = h - 2\text{clearcover} - D_T - 0,5D_L$$

$$= 3000 - (50) - 16 - (0,5 \cdot 29)$$

$$= 3920 \text{ mm}$$

$$V_c = \left(1 + \frac{2646040}{14 \times 6000000} \right) \frac{\sqrt{40}}{6} \cdot 2000 \cdot 3920$$

$$= 8523321 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 8523321$$

$$= 5966325 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 5966325 = 2983162 \text{ N}$$

$$V_u = V_y = 918410 \text{ N} < 0,5 \phi V_c = 2983162$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 3 kaki,

$$A_v = 3 \cdot 0,25 \pi D^2 = 3 \cdot 0,25 \cdot \pi \cdot 16^2 = 603 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 603 \times 400}{2000} = 362 \text{ mm}$$

Tinjauan geser pada sumbu lemah (arah y):

$$V_c = \left(1 + \frac{N_u}{14 A_g} \right) \frac{\sqrt{f_c'}}{6} b_w d$$

$$A_g = 6000000 \text{ mm}^2$$

$$b_w = 3000 \text{ mm}$$

$$d = b - 2 \text{clearcover} - D_T - 0,5 D_L$$

$$= 2000 - (50) - 16 - (0,5 \cdot 29)$$

$$= 1920 \text{ mm}$$

$$V_c = \left(1 + \frac{2646040}{14 \times 6000000} \right) \frac{\sqrt{40}}{6} \cdot 3000 \cdot 1920$$

$$= 6070036 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 6070036$$

$$= 4249025 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 4249025 = 2124512 \text{ N}$$

$$V_u = V_x = 1859580 \text{ N} < 0,5 \phi V_c = 2124512 \text{ N}$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 4 kaki,

$$A_v = 4 \cdot 0,25 \pi D^2 = 4 \cdot 0,25 \cdot \pi \cdot 16^2 = 804 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 804 \times 400}{3000} = 322 \text{ mm}$$

Tinjauan terhadap torsi:

Pengaruh torsi boleh diabaikan bila persamaan berikut terpenuhi.

$$T_u < \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$$

$$T_u = 0 \text{ N-mm}$$

$$A_{cp} = 2000 \cdot 3000 = 6000000 \text{ mm}^2$$

$$p_{cp} = 2 \cdot (2000 + 3000) = 10000 \text{ mm}$$

$$\begin{aligned} \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right) &= 0,75 \cdot 0,083 \cdot \sqrt{40} \left(\frac{6000000^2}{10000} \right) \\ &= 1417332847 \text{ N-mm} < T_u \end{aligned}$$

Persamaan di atas memenuhi dengan $T_u < 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$ sehingga pengaruh torsi dapat diabaikan.

c) Section-C-C

Gaya geser maksimum desain:

$$V_y = 324590 \text{ N}$$

$$f'c' = 40 \text{ MPa}$$

$$V_x = 685710 \text{ N}$$

$$f_y = 400 \text{ MPa}$$

$$T_u = 224110000 \text{ N-mm}$$

$$D_T = 16 \text{ mm}$$

$$N_u = 15693460 \text{ N}$$

Tinjauan geser pada sumbu kuat (arah x):

$$V_c = \left(1 + \frac{N_u}{14A_g} \right) \frac{\sqrt{f'c'}}{6} b_w d$$

$$A_g = 6180000 \text{ mm}^2$$

$$b_w = 2000 \text{ mm}$$

$$d = h - 2\text{clearcover} - D_T - 0,5D_L$$

$$= 4000 - (50) - 16 - (0,5 \cdot 32)$$

$$= 3918 \text{ mm}$$

$$V_c = \left(1 + \frac{15693460}{14 \times 6180000} \right) \frac{\sqrt{40}}{6} \cdot 2000 \cdot 3918$$

$$= 9758088 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 9758088$$

$$= 6830662 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 6830662 = 3415331 \text{ N}$$

$$V_u = V_y = 324590 \text{ N} < 0,5 \phi V_c = 3415331$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 3 kaki,

$$A_v = 3 \cdot 0,25 \pi D^2 = 3 \cdot 0,25 \cdot \pi \cdot 16^2 = 603 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 603 \times 400}{2000} = 362 \text{ mm}$$

Tinjauan geser pada sumbu lemah (arah y):

$$V_c = \left(1 + \frac{N_u}{14 A_g} \right) \frac{\sqrt{f_c}}{6} b_w d$$

$$A_g = 6180000 \text{ mm}^2$$

$$b_w = 4000 \text{ mm}$$

$$d = b - 2 \text{clearcover} - D_T - 0,5 D_L$$

$$= 2000 - (50) - 16 - (0,5 \cdot 32)$$

$$= 1918 \text{ mm}$$

$$V_c = \left(1 + \frac{15693460}{14 \times 6180000} \right) \frac{\sqrt{40}}{6} \cdot 4000 \cdot 1918$$

$$= 8087054 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 8087054$$

$$= 5660938 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 5660938 = 2830469 \text{ N}$$

$$V_u = V_x = 685710 \text{ N} < 0,5 \phi V_c = 2830469 \text{ N}$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 5 kaki,

$$A_v = 5 \cdot 0,25 \pi D^2 = 5 \cdot 0,25 \cdot \pi \cdot 16^2 = 1005 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 1005 \times 400}{4000} = 302 \text{ mm}$$

Tinjauan terhadap torsi:

Pengaruh torsi boleh diabaikan bila persamaan berikut terpenuhi.

$$T_u < \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$$

$$T_u = 224110000 \text{ N-mm}$$

$$A_{cp} = 6180000 \text{ mm}^2$$

$$p_{cp} = 12000 \text{ mm}$$

$$\begin{aligned} \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right) &= 0,75 \cdot 0,083 \cdot \sqrt{40} \left(\frac{6180000^2}{12000} \right) \\ &= 1253040348 \text{ N-mm} < T_u \end{aligned}$$

Persamaan di atas memenuhi dengan $T_u < 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$ sehingga pengaruh torsi dapat diabaikan.

d) Section-D-D

Gaya geser maksimum desain:

$$V_y = 613800 \text{ N}$$

$$f'c' = 40 \text{ MPa}$$

$$V_x = 616010 \text{ N}$$

$$f_y = 400 \text{ MPa}$$

$$T_u = 0 \text{ N-mm}$$

$$D_T = 16 \text{ mm}$$

$$N_u = 3346440 \text{ N}$$

Tinjauan geser pada sumbu kuat (arah x):

$$V_c = \left(1 + \frac{N_u}{14A_g} \right) \frac{\sqrt{f'c'}}{6} b_w d$$

$$A_g = 2250000 \text{ mm}^2$$

$$b_w = 1500 \text{ mm}$$

$$d = h - 2\text{clearcover} - D_T - 0,5D_L$$

$$= 1500 - (50) - 16 - (0,5 \cdot 25)$$

$$= 1422 \text{ mm}$$

$$V_c = \left(1 + \frac{3346440}{14 \times 2250000} \right) \frac{\sqrt{40}}{6} \cdot 1500 \cdot 1422$$

$$= 2486364 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 2486364$$

$$= 1740455 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 1740455 = 870227 \text{ N}$$

$$V_u = V_y = 613800 \text{ N} < 0,5 \phi V_c = 870227$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 2 kaki,

$$A_v = 2 \cdot 0,25 \pi D^2 = 2 \cdot 0,25 \cdot \pi \cdot 16^2 = 402 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 402 \times 400}{1500} = 322 \text{ mm}$$

Tinjauan geser pada sumbu lemah (arah y):

$$V_c = \left(1 + \frac{N_u}{14 A_g} \right) \frac{\sqrt{f_c'}}{6} b_w d$$

$$A_g = 2250000 \text{ mm}^2$$

$$b_w = 1500 \text{ mm}$$

$$d = h - 2 \text{clearcover} - D_T - 0,5 D_L$$

$$= 1500 - (50) - 16 - (0,5 \cdot 25)$$

$$= 1422 \text{ mm}$$

$$V_c = \left(1 + \frac{3346440}{14 \times 2250000} \right) \frac{\sqrt{40}}{6} \cdot 1500 \cdot 1422$$

$$= 2486364 \text{ N}$$

$$\phi V_c = 0,7 \cdot V_c$$

$$= 0,7 \cdot 2486364$$

$$= 1740455 \text{ N}$$

$$0,5 \phi V_c = 0,5 \cdot 1740455 = 870227 \text{ N}$$

$$V_u = V_y = 613800 \text{ N} < 0,5 \phi V_c = 870227$$

Karena $V_u < 0,5 \phi V_c$ maka penampang sudah cukup kuat menahan gaya geser yang terjadi, sehingga tidak diperlukan tulangan geser. Tetapi untuk keamanan dipasang tulangan geser minimum yang dihitung berdasarkan 5.2.7 sebagai berikut:

$$A_{v(\min)} = \frac{1}{3} \frac{b_w s}{f_y}$$

Digunakan D16 dengan 2 kaki,

$$A_v = 2 \cdot 0,25 \pi D^2 = 2 \cdot 0,25 \cdot \pi \cdot 16^2 = 402 \text{ mm}^2$$

$$s = \frac{3 A_v f_y}{b_w} = \frac{3 \times 402 \times 400}{1500} = 322 \text{ mm}$$

Tinjauan terhadap torsi:

Pengaruh torsi boleh diabaikan bila persamaan berikut terpenuhi.

$$T_u < \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$$

$$T_u = 0 \text{ N-mm}$$

$$A_{cp} = 2250000 \text{ mm}^2$$

$$p_{cp} = 6000 \text{ mm}$$

$$\begin{aligned} \phi 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right) &= 0,75 \cdot 0,083 \cdot \sqrt{40} \left(\frac{2250000^2}{6000} \right) \\ &= 332187386 \text{ N-mm} < T_u \end{aligned}$$

Persamaan di atas memenuhi dengan $T_u < 0,083 \sqrt{f'c'} \left(\frac{A_{cp}^2}{p_{cp}} \right)$ sehingga pengaruh torsi dapat diabaikan.

5.3.2.2 Persyaratan Jarak Tulangan

Persyaratan mengenai penulangan transversal diatur dalam SNI T 12 2004 Pasal 5.7.8.4. Jarak antara sengkang tidak melebihi harga terkecil dari:

- $0,5 h_c$:
 - Section-A-A = $0,5 \cdot 4000 = 2000 \text{ mm}$
 - Section-B-B = $0,5 \cdot 3000 = 1500 \text{ mm}$
 - Section-C-C = $0,5 \cdot 4000 = 2000 \text{ mm}$
 - Section-D-D = $0,5 \cdot 1500 = 750 \text{ mm}$
- $7,5 d_b$ = $7,5 \cdot 32 = 240 \text{ mm}$
 - $7,5 \cdot 29 = 218 \text{ mm}$
 - $7,5 \cdot 25 = 188 \text{ mm}$
- 300 mm

Berdasarkan analisa penulangan geser dan persyaratan jarak tulangan, digunakan:

- Section-A-A
 - Tulangan geser sumbu kuat : 3D16 – 200 mm
 - Tulangan geser sumbu lemah : 5D16 – 200 mm
- Section-B-B

- Tulangan geser sumbu kuat : 3D16 – 200 mm
- Tulangan geser sumbu lemah : 4D16 – 200 mm
- Section-C-C
 - Tulangan geser sumbu kuat : 3D16 – 200 mm
 - Tulangan geser sumbu lemah : 5D16 – 200 mm
- Section-D-D
 - Tulangan geser sumbu kuat : 2D16 – 150 mm
 - Tulangan geser sumbu lemah : 2D16 – 150 mm

2.7.4 Analisa Angkur pada Pylon

Desain angkur pada pylon meliputi *bearing plate* yang menahan tegangan akibat gaya tarik kabel dan juga kontrol tegangan pada beton akibat gaya tarik kabel. Gaya tarik kabel diberikan sebagai berikut.

Tabel 0.3 - Gaya dalam pada kabel

Kabel	Force(kN)
S1	2700
S2	2400
S3	2100
S4	1800
S5	1600
S6	1400
S7	1200
S8	1000

Penampang kabel seperti telah didesain pada bab sebelumnya diberikan sebagai berikut.

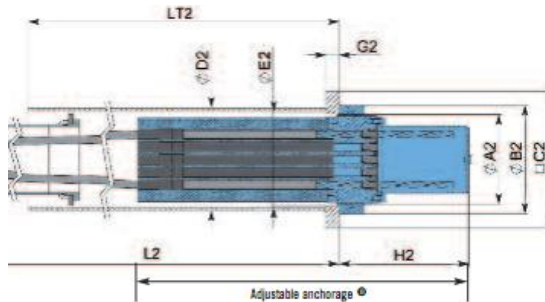
Lebar pelat angkur, $[C2] = 600 \text{ mm}$

Diameter angkur kabel, $\phi A2 = 385 \text{ mm}$

Panjang pengankuran, $LT2 = 1100 \text{ mm}$

$$Ap' = LT1^2 = 1100^2 = 1210000 \text{ mm}^2$$

$$Ap = [C2^2 - 0,25\pi\phi A2^2 = 600^2 - (0,25 \cdot \pi \cdot 385^2) \\ = 243584,35 \text{ mm}^2$$



Gambar 5. 88 Detail adjustable anchorage VSL SSI 2000

Tegangan tekan pada beton diambil sebesar 85% f_c' .

$$f_c = 0,85 \cdot f_c' = 0,85 \cdot 40 = 34 \text{ MPa}$$

Tegangan ijin beton di bawah pelat angkur dihitung sebagai berikut:

$$\begin{aligned} f_{cp} &= 0,8 \cdot f_c \sqrt{\frac{Ap'}{Ap} - 0,2} \\ &= 0,8 \cdot 34 \cdot \sqrt{\frac{1210000}{243584,35} - 0,2} \\ &= 60,62 \text{ MPa} \end{aligned}$$

Tegangan yang terjadi di bawah pelat angkur dihitung sebagai berikut:

Gaya tarik maksimum, $P_u = 2700000 \text{ N}$

Tegangan tarik:

$$f_t = \frac{P_u}{Ap} = \frac{2700000}{243584,35} = 11,08 \text{ MPa} < f_{cp} = 60,62 \text{ MPa}$$

.....[memenuhi]

(halaman ini sengaja dikosongkan)

BAB VI

PERENCANAAN STRUKTUR BAWAH

6.1 Analisa Pondasi

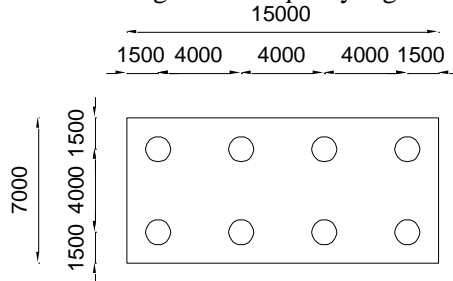
Dalam perencanaan struktur bangunan bawah jembatan ini direncanakan menggunakan *pile cap* beserta perencanaan pondasinya.

Data Umum Jembatan

Berikut merupakan data umum jembatan busur rencana:

- Lokasi jembatan = Kabupaten Probolinggo
- Bentang jembatan = 144 m
- Lebar jembatan = 20,5 m
- Struktur atas = Struktur *cabl-stayed*
- Pondasi = Pondasi *borepile* $d = 1,2$ m
- Zona gempa = 4

Berikut adalah konfigurasi *borepile* yang direncanakan.



Gambar 6. 1 Denah pondasi

Jarak antar tiang

S = jarak antar tiang

$$3D < S < 8D$$

$$3.1200 < S < 8.1200$$

$$3600 < S < 9600$$

$$\text{Dipakai } S = 4000 \text{ mm}$$

$S1$ = jarak tiang ke tepi

$$1D < S1 < 1,5D$$

$$1200 < S1 < 1,5.1200$$

$$1200 < S1 < 1800$$

$$\text{Dipakai } S1 = 1500 \text{ mm}$$

Jumlah tiang = 8 tiang dalam satu *pilecap*.

Depth	N-SPT	Eo = 28 N	ko	k	kv	kx	kx = ky
(m)		kg/cm ²	kg/cm ³	kg/cm ³	T/m	kg/cm	kg/m
0	0	0	0	0	0	0	0
-1	5	140.000	0.77	0.772275	757813	9267	926730
-2	10	280.000	1.54	1.54455	378906	37069	37069210
-3	15	420.000	2.32	2.316826	252604	83406	8340572
-4	20	560.000	3.09	3.089101	189453	148277	14827684
-5	40	1120.000	6.18	6.178202	151563	370692	37069210
-6	60	1680.000	9.27	9.267303	126302	667246	66724579
-7	60	1680.000	9.27	9.267303	108259	778453	77845342
-8	61	1708.000	9.42	9.421758	94727	904489	90448873
-9	61	1708.000	9.42	9.421758	84201	1017550	101754982
-10	62	1736.000	9.58	9.576213	75781	1149146	114914552
-11	55	1540.000	8.50	8.495027	68892	1121344	112134361
-12	46	1288.000	7.10	7.104932	63151	1023110	102311020
-13	48	1344.000	7.41	7.413842	58293	1156559	115655936
-14	49	1372.000	7.57	7.568297	54129	1271474	127147391
-15	57	1596.000	8.80	8.803937	50521	1584709	158470874
-16	64	1792.000	9.89	9.885123	47363	1897944	189794357
-17	62	1736.000	9.58	9.576213	44577	1953547	195354738
-18	60	1680.000	9.27	9.267303	42101	2001737	200173736
-19	63	1764.000	9.73	9.730668	39885	2218592	221859224
-20	65	1820.000	10.04	10.03958	37891	2409499	240949867
-21	63	1764.000	9.73	9.730668	36086	2452128	245212826
-22	60	1680.000	9.27	9.267303	34446	2446568	244656788
-23	60	1680.000	9.27	9.267303	32948	2557776	255777551
-24	60	1680.000	9.27	9.267303	31576	2668983	266898314
-25	60	1680.000	9.27	9.267303	30313	2780191	278019077
-26	60	1680.000	9.27	9.267303	29147	2891398	289139840
-27	60	1680.000	9.27	9.267303	28067	3002606	300260603
-28	60	1680.000	9.27	9.267303	27065	3113814	311381367
-29	60	1680.000	9.27	9.267303	26131	3225021	322502130
-30	60	1680.000	9.27	9.267303	25260	3336229	333622893

Gambar 6. 2 Perhitungan spring

Dari perhitungan gaya aksial yang terjadi akibat kombinasi beban pada 1 tiang bor (*bored pile*) didapatkan gaya aksial terbesar yang diterima adalah 832,66 Tonf, selanjutnya gaya aksial yang harus terjadi harus lebih kecil dari daya dukung tanah. Untuk lebih jelas dapat dilihat dalam tabel berikut.

TERJADI			
P beban tetap		P beban sementara	
P tekan	P cabut	P tekan	P cabut
(t)	(t)	(t)	(t)
663.66	0	832.66	0

Gambar 6. 3 Hasil permodelan

6.1.1 Perhitungan Daya Dukung Tanah

Dari tabel dapat diketahui nilai maksimum (P max) Gaya aksial tiang pancang akibat beban tetap adalah 663,66 Tonf, sedangkan nilai maksimum (P max) Gaya aksial tiang pancang akibat beban sementara adalah 832,66 kN.

Daya dukung vertikal

- Daya dukung terpusat tiang

$$R_p = q_d \cdot A$$

- Gaya geser dinding tiang

$$R_f = U \sum l_i \cdot f_i$$

- Daya dukung ultimit

$$R_u = R_p + R_f$$

- Daya dukung vertikal ijin

$$R_a = \frac{1}{n} (R_u - W_s) + W_s - W_p$$

dimana,

n = faktor keamanan

R_u = Daya dukung ultimate (ton)

R_p = Daya dukung terpusat tiang (ton)

R_f = Gaya geser dinding tiang (ton)

W_s = Berat efektif tanah yang dipindahkan (ton)

W_p = Berat efektif tiang (ton)

Data Perencanaan Tiang bor / bored pile :

$D_{\text{bored pile}} = 120 \text{ cm}$

$= 1,2 \text{ m}$

$A_p = 1,130 \text{ m}^2$

$U = 3,768 \text{ m}$

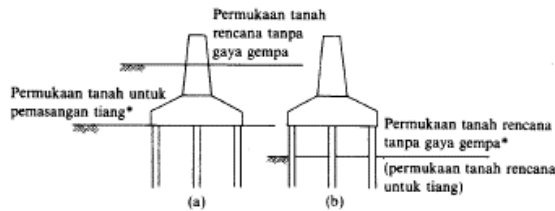
$n = 2$, untuk beban gempa

$n = 3$, untuk beban tetap

Tabel 6. 1 Perhitungan daya dukung ijin tanah

Depth (m)	N spt	$f_i \text{ (t/m}^2\text{)}$	$\Sigma f_i \times l_i$ (t/m)	$R_f \text{ (ton)}$	$R_p \text{ (ton)}$	$R_u \text{ (ton)}$	Sf = 3	Sf = 2	Sf = 3	Sf = 2
							P tekan (ton)	Ptekan (ton)	P cabut (ton)	P cabut (ton)
0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-1	5	2.5	2.5	9.4	90.5	99.9	33.3	50.0	3.1	4.7
-2	10	5	7.5	28.3	181.0	209.2	69.7	104.6	9.4	14.1
-3	15	12	19.5	73.5	271.4	344.9	115.0	172.5	24.5	36.8
-4	20	12	31.5	118.8	361.9	480.7	160.2	240.3	39.6	59.4
-5	40	12	43.5	164.0	723.8	887.8	295.9	443.9	54.7	82.0
-6	60	12	55.5	209.2	1085.7	1295.0	431.7	647.5	69.7	104.6
-7	60	12	67.5	254.5	1085.7	1340.2	446.7	670.1	84.8	127.2
-8	61	12	79.5	299.7	1103.8	1403.5	467.8	701.8	99.9	149.9
-9	61	12	91.5	344.9	1103.8	1448.8	482.9	724.4	115.0	172.5
-10	62	12	103.5	390.2	1121.9	1512.1	504.0	756.1	130.1	195.1
-11	55	12	115.5	435.4	995.3	1430.7	476.9	715.3	145.1	217.7
-12	46	12	127.5	480.7	832.4	1313.1	437.7	656.5	160.2	240.3
-13	48	12	139.5	525.9	868.6	1394.5	464.8	697.2	175.3	263.0
-14	49	12	151.5	571.1	886.7	1457.8	485.9	728.9	190.4	285.6
-15	57	12	163.5	616.4	1031.4	1647.8	549.3	823.9	205.5	308.2
-16	64	12	175.5	661.6	1158.1	1819.7	606.6	909.9	220.5	330.8
-17	62	12	187.5	706.9	1121.9	1828.8	609.6	914.4	235.6	353.4
-18	60	12	199.5	752.1	1085.7	1837.8	612.6	918.9	250.7	376.0
-19	63	12	211.5	797.3	1140.0	1937.4	645.8	968.7	265.8	398.7
-20	65	12	223.5	842.6	1176.2	2018.8	672.9	1009.4	280.9	421.3
-21	63	12	235.5	887.8	1140.0	2027.8	675.9	1013.9	295.9	443.9
-22	60	12	247.5	933.1	1085.7	2018.8	672.9	1009.4	311.0	466.5
-23	60	12	259.5	978.3	1085.7	2064.0	688.0	1032.0	326.1	489.1
-24	60	12	271.5	1023.5	1085.7	2109.3	703.1	1054.6	341.2	511.8
-25	60	12	283.5	1068.8	1085.7	2154.5	718.2	1077.3	356.3	534.4
-26	60	12	295.5	1114.0	1085.7	2199.7	733.2	1099.9	371.3	557.0
-27	60	12	307.5	1159.2	1085.7	2245.0	748.3	1122.5	386.4	579.6
-28	60	12	319.5	1204.5	1085.7	2290.2	763.4	1145.1	401.5	602.2
-29	60	12	331.5	1249.7	1085.7	2335.5	778.5	1167.7	416.6	624.9
-30	60	12	691.5	2606.9	1085.7	3692.6	1230.9	1846.3	869.0	1303.4

▪ Kontrol Tiang:



*Tempat di mana besarnya perpindahan normal dapat diketahui

Gbr. 6.11 Cara untuk menentukan permukaan tanah rencana untuk tiang.

Tiang-tiang terbenam di dalam tanah (Gbr. 6.11(a))

$$H_a = \frac{k \cdot D}{\beta} \cdot \delta_a \quad (6.8)$$

Tiang-tiang menonjol di atas tanah (Gbr. 6.11(b))

$$H_a = \frac{4EI \cdot \beta^3}{1 + \beta h} \cdot \delta_a \quad (6.9)$$

H_a = kapasitas daya dukung horizontal tiang

E = Modulus Elastisitas bahan

I = momen inersia penampang

δ_a = pergeseran normal (diambil sebesar 1 cm)

k = koefisien reaksi tanah dasar

$$= k_o y^{-0.5}$$

$$= k_o = 0,2 E_o D^{-3/4} \text{ (nilai } k \text{ apabila pergeseran diambil sebesar 1 cm)}$$

y = besarnya pergeseran yang dicari

E_o = Modulus elastisitas tanah (28 N)

h =Tinggi tiang yag menonjol di atas permukaan tanah

Daya dukung horizontal tiang borepile D-1800:

$$E = 4700 \times \sqrt{f'c'} = 29725 \text{ MPa}$$

$$N \text{ rata rata} = 61,86$$

$$E_o = 28 \text{ Nspt} = 1820 \text{ kg/cm}^2$$

$$\text{Pergeseran tiang di dasar pile cap } (\delta) = 1 \text{ cm}$$

$$I = 10178760 \text{ cm}^4$$

$$k = 10,03 \text{ kg/cm}^4$$

$$\beta = 4 \sqrt{\frac{k \times D}{4 \times E \times I}} = 0,005 \text{ cm}$$

Daya Dukung Gaya Horizontal Tiang Tegak

$$\delta a = 1 \text{ cm}$$

$$\begin{aligned} H_a &= \frac{k D}{\beta} \delta a \\ &= \left(\frac{10,03 \times 120}{0,001} \times 1,00 \right) / 1000 \\ &= 214,48 \text{ ton} \end{aligned}$$

$$\begin{aligned} H &= H_a / \text{jumlah tiang} \\ &= 214,8 / 8 \\ &= 26,81 \text{ ton/tiang} \end{aligned}$$

$$SF = 3$$

$$\begin{aligned} H_a / SF &= 214,8 \text{ ton} / 3 \\ &= 71,49 \text{ ton} > H \text{ 1 tiang (memenuhi syarat)} \end{aligned}$$

$$SF = 2$$

$$\begin{aligned} H_a / SF &= 214,8 \text{ ton} / 2 \\ &= 107,24 \text{ ton} > H \text{ 1 tiang (memenuhi syarat)} \end{aligned}$$

Tabel 6. 2 Reaksi yang terjadi pada borepile

PERSYARATAN				TERJADI			
P ijin beban tetap		P ijin beban sementara		P beban tetap		P beban sementara	
P tekan (t)	P cabut (t)	P tekan (t)	P cabut (t)	P tekan	P cabut	P tekan	P cabut
(SF = 3)	(SF = 3)	(SF = 2)	(SF = 2)	(t)	(t)	(t)	(t)
672.93	280.86	1009.39	421.29	663.66	0	832.66	0

6.1.2 Perhitungan penulangan bored pile

- Penulangan lentur

Rekapitulasi gaya pada bored pile :

$$P = 8326.60 \text{ kN}$$

$$V = 139.90 \text{ kN}$$

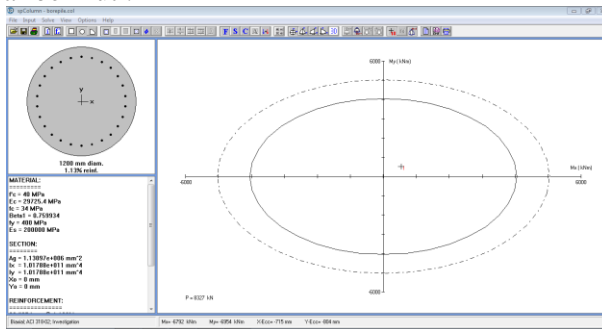
$$M = 539.30 \text{ kN.m}$$

$$k = 1,5$$

$$P_u = 12489.9 \text{ kN}$$

$$\begin{aligned}
 V_u &= 209.85 \text{ kN} \\
 M_u &= 808.95 \text{ kN.m} \\
 f_c' &= 40 \text{ MPa} \\
 D &= 1200 \text{ mm} \\
 L &= 20000 \text{ mm} \\
 d' &= 100 \text{ mm} \\
 d &= 1100 \text{ mm} \\
 f_y &= 390 \text{ MPa}
 \end{aligned}$$

dilakukan input gaya dan spek yang dipakai untuk tiang bor pada program pcaCol, sehingga didapatkan grafik pada gambar berikut :



Gambar 6. 4 grafik hasil input SpCacool, hubungan antara momen dan gaya aksial

Tulangan pakai : 26 D 25 ($A_s = 12766 \text{ mm}^2$) dengan rasio tulangan 1,13%

- *Penulangan geser*

Cek kekuatan geser beton

$$\begin{aligned}
 V_c &= \frac{1}{6} \sqrt{f_c'} b d \\
 &= \frac{1}{6} \sqrt{40} 1100 \times 20000 \\
 &= 23190036 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 V_s \text{ min} &= \frac{B \cdot D}{3} \\
 &= \frac{1320000}{3} = 440000 \text{ N}
 \end{aligned}$$

Cek kondisi geser

1. $V_u < 0.5 \times \phi \times V_c$
 $139900.0 < 8116513$ ok
2. $0.5 \times \phi \times V_c < V_u < \phi \times V_c$
 $8116513 > 139900,0 < 16233025$ not ok
3. $\phi \times V_c < V_u < \phi (V_c + V_s \text{ min})$
 $16233025 > 139900,0 < 16541025$ not o
4. $\phi (V_c + V_s \text{ min}) < V_u < \phi (V_c + 1/3 \sqrt{f_c'} \text{ bw d})$
 $16541025 > 139900,0 < 18180988$ not o
5. $\phi (V_c + 1/3 \sqrt{f_c'} \text{ bw d}) < V_u < \phi (V_c + 2/3 \sqrt{f_c'} \text{ bw d})$
 $18180988 > 2599996,0 < 20128951$ not ok

Didapatkan dari perhitungan diatas masuk pada kondisi 1

Maka dipasang tulangan geser praktis $\emptyset 13 - 150$

6.1.3 Panjang penyaluran

a. Perhitungan Panjang Penyaluran Tulangan

Berdasarkan SNI 2847-2013 pasal 12.2 untuk penyaluran batang ulir dan kawat ulir yang berada dalam kondisi tarik untuk batang dengan diameter 22 atau lebih besar dapat digunakan persamaan berikut:

$$\frac{l_d}{d_b} = \frac{3 f_y \alpha \beta \gamma \lambda}{5 \sqrt{f_c'}}$$

Berdasarkan SNI 03-2847-2002 pasal 14.2.4

α = faktor lokasi penulangan

Tulangan horizontal yang selain ditempatkan sedemikian hingga lebih dari 300 mm beton segar dicor pada komponen di bawah panjang penyaluran atau sambungan yang ditinjau dapat diambil sebesar 1

β = faktor pelapis

Tulangan utama tanpa pelapis dapat diambil sebesar 1

γ = faktor ukuran batang tulangan

Untuk batang D-22 atau lebih besar diambil sebesar 1

λ = faktor beton agregat ringan

Apabila digunakan beton berat normal diambil sebesar 1

$$\frac{Id}{db} = \frac{3}{5} \frac{fy \beta \alpha \gamma}{\sqrt{fc'}}$$

$$\frac{Id}{db} = \frac{3}{5} \frac{390 \text{ N/mm}^2 \cdot 1.1.1.1}{\sqrt{40}}$$

$$I_d = 925 \text{ mm}$$

Berdasarkan SNI 2847-2013 pasal 12.2 untuk penyaluran batang ulir dan kawat ulir yang berada dalam kondisi tekan untuk batang dengan diameter 22 atau lebih besar dapat digunakan persamaan berikut:

$$\frac{l_{dh}}{d_b} = \frac{0,24fy}{\lambda \sqrt{fc'}} = \frac{0,24 \times 390}{1 \cdot \sqrt{40}} \approx 370 \text{ mm}$$

Tidak boleh kurang dari :

$$\begin{aligned} 0,04 \times d_b \times fy &= 0,04 \times 25 \times 390 \\ &= 390 \text{ mm} \end{aligned}$$

Maka dipasang panjang penyaluran terbesar yaitu 925 mm \approx 1000 mm

6.2 Perhitungan Tulangan Pile Cap

Untuk momen pada Pile Cap didapat dari analisa abutment

- Tulangan Arah Vertikal

$$Mu = 59087510 \text{ Nmm}$$

$$fc' = 40 \text{ MPa}$$

$$fy = 390 \text{ MPa}$$

$$D \text{ tulangan} = 36 \text{ mm}$$

$$h = 2500 \text{ mm}$$

$$d' = 50 \text{ mm}$$

$$d = h - d' - D \text{ tulangan}$$

$$= 2500 - 50 - 36$$

$$= 2414 \text{ mm}$$

$$= 2,414 \text{ m}$$

$$m = \frac{fy}{0,85 \times fc'}$$

$$= \frac{390}{0,85 \times 40} = 11,5$$

$$Mn = \frac{Mu}{\phi}$$

$$= \frac{59087510}{0,8} = 73859387,5 \text{ Nmm}$$

$$\begin{aligned}
 R_n &= \frac{M_n}{b \times d^2} \\
 &= \frac{73859387}{1000 \times 2414^2} \\
 &= 0,013 \text{ N/mm}^2 \\
 \rho_{\text{balance}} &= \frac{0,85 \times \beta_1 \times f_{c'}}{f_y} \times \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 0,85 \times 40}{390} \times \left(\frac{600}{600 + 390} \right) \\
 &= 0,041 \\
 \rho_{\text{min}} &= \frac{1,4}{f_y} \\
 &= \frac{1,4}{390} \\
 &= 0,004 \\
 \rho_{\text{max}} &= 75\% \times \rho_{\text{balance}} \\
 &= 75\% \times 0,041 \\
 &= 0,031 \\
 \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\
 &= \frac{1}{11,5} \left(1 - \sqrt{1 - \frac{2 \times 11,5 \times 0,013}{390}} \right) \\
 &= 0,000033
 \end{aligned}$$

Kontrol, $\rho_{\text{min}} > \rho_{\text{perlu}} > \rho_{\text{max}}$

Karena dari kontrol yang didapat $\rho_{\text{perlu}} < \rho_{\text{min}}$ maka digunakan $\rho_{\text{min}} = 0,004$

$$\begin{aligned}
 A_s &= \rho \times b \times d \\
 &= 0,004 \times 1000 \times 2414 \\
 &= 8665,6 \text{ mm}^2
 \end{aligned}$$

Maka untuk tulangan arah vertikal digunakan **D36- 100** ($A_s = 10179 \text{ mm}^2$)

- Tulangan Arah Horizontal

M_u	$= 89393840 \text{ Nmm}$
$f_{c'}$	$= 40 \text{ MPa}$
f_y	$= 390 \text{ MPa}$
D tulangan	$= 36 \text{ mm}$
h	$= 2500 \text{ mm}$
d'	$= 50 \text{ mm}$

$$\begin{aligned}
 d &= h - d' - D \text{ tulangan} \\
 &= 2500 - 50 - 36 \\
 &= 2414 \text{ mm} \\
 &= 2,414 \text{ m}
 \end{aligned}$$

$$\begin{aligned}
 m &= \frac{f_y}{0,85 \times f_{c'} \times 390} \\
 &= \frac{0,85 \times 40}{390} = 11,5
 \end{aligned}$$

$$\begin{aligned}
 M_n &= \frac{M_u}{\phi} \\
 &= \frac{89393840}{0,8} \\
 &= 111742300 \text{ Nmm}
 \end{aligned}$$

$$\begin{aligned}
 R_n &= \frac{M_n}{b \times d^2} \\
 &= \frac{111742300}{1000 \times 2414^2} \\
 &= 0,019 \text{ N/mm}^2
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{balance}} &= \frac{0,85 \times \beta_1 \times f_{c'}}{f_y} \times \left(\frac{600}{600 + f_y} \right) \\
 &= \frac{0,85 \times 0,85 \times 40}{390} \times \left(\frac{600}{600 + 390} \right) \\
 &= 0,041
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{min}} &= \frac{1,4}{f_y} \\
 &= \frac{1,4}{390} \\
 &= 0,004
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{max}} &= 75\% \times \rho_{\text{balance}} \\
 &= 75\% \times 0,041 \\
 &= 0,031
 \end{aligned}$$

$$\begin{aligned}
 \rho_{\text{perlu}} &= \frac{1}{m} \left(1 - \sqrt{1 - \frac{2 \times m \times R_n}{f_y}} \right) \\
 &= \frac{1}{11,5} \left(1 - \sqrt{1 - \frac{2 \times 11,5 \times 0,019}{390}} \right) \\
 &= 0,000049
 \end{aligned}$$

Kontrol, $\rho_{\text{min}} > \rho_{\text{perlu}} > \rho_{\text{max}}$

Karena dari kontrol yang didapat ρ perlu $< \rho$ min maka digunakan ρ min = 0,004

$$\begin{aligned} A_s &= \rho \times b \times d \\ &= 0,004 \times 1000 \times 2414 \\ &= 8665,6 \text{ mm}^2 \end{aligned}$$

Maka untuk tulangan arah vertikal digunakan **D36- 100** ($A_s = 10179 \text{ mm}^2$)

Kontrol geser pons

$$\begin{aligned} B_w &= \text{keliling pancang} + \text{tebal poer} \\ &= 7769,91 \text{ mm} \end{aligned}$$

$$\begin{aligned} V_c &= \frac{1}{6} \sqrt{f_c} b_w d \\ &= \frac{1}{6} \cdot \sqrt{40} \cdot 7769,91 \cdot 3862 \\ &= 31634668,82 \text{ N} \end{aligned}$$

$$V_u = \frac{P_{max}}{0,75} = \frac{832,66}{0,75} = 11102133,3 \text{ N}$$

Syarat :

$$\begin{aligned} V_c &> V_u \\ 31634668,82 \text{ N} &> 11102133,3 \text{ N} \\ &\text{(Tebal Poer Memenuhi)} \end{aligned}$$

▪ Kontrol Geser

$$\begin{aligned} V_u &= 11102133,3 \text{ N} \\ V_u \text{ max} &= 0,2 \times f_c \times b_w \times d \\ &= 240090255,6 \text{ N} \\ \Phi V_c &= 0,9 \times V_{u \text{ max}} \\ &= 0,9 \times 240090255,6 \text{ N} \\ &= 216081230 \text{ N} \end{aligned}$$

$$V_u < \Phi V_c \text{ (Kehancuran badan tidak akan terjadi)}$$

BAB VII

PELAKSANAAN DAN MAINTENANCE

Pada bab ini akan dibahas metode pelaksanaan dalam konstruksi jembatan *cable stayed* ini, sekaligus analisa stuktur ketika *maintenance*. Metode pelaksanaan mencakup pemasangan dek jembatan dan kontrol keamanan struktur ketika pemasangan dek. Sedangkan analisa struktur ketika *maintenance* mencakup pelepasan 1 buah kabel untuk diganti dan bagaimana pengaruhnya terhadap struktur jembatan.

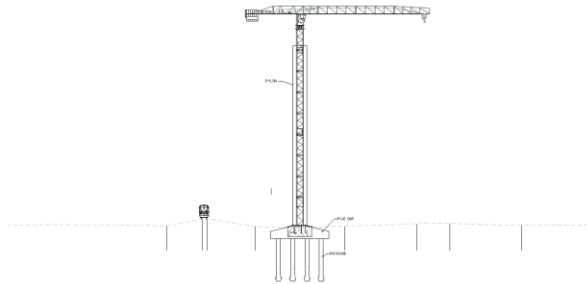
7.1 Metode Pelaksanaan

Metode pelaksanaan yang digunakan adalah *balance cantilever method*. Untuk memasang dek digunakan *lifting frame* dan juga digunakan bantuan perancah untuk memasang masing-masing segmen dek jembatan.

Tahapan pelaksanaan diuraikan sebagai berikut:

a) Tahap Pertama

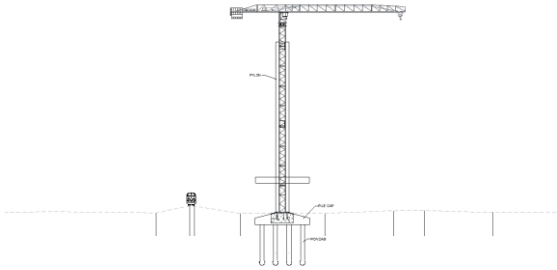
Tahap pertama, didirikan bangunan bawah yaitu pondasi dan pillar kemudian *pylon* sebagaimana terlihat pada gambar di bawah.



Gambar 7. 1 Tahap pertama pelaksanaan

b) Tahap Kedua

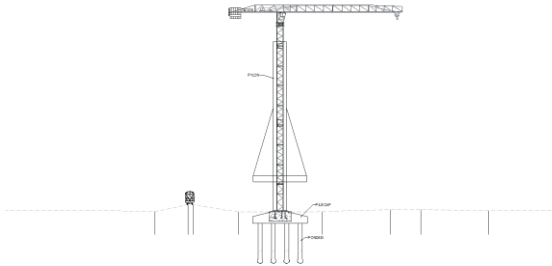
Pada tahap kedua, segmen dek pertama dipasang menggunakan *crane* dan perancah di atas *pillar*, sebagaimana terlihat pada gambar berikut.



Gambar 7. 2 Tahap kedua pelaksanaan

c) Tahap Ketiga

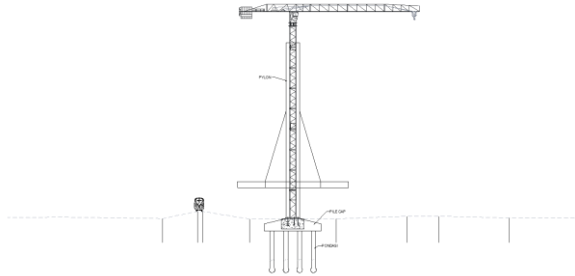
Pada tahap kelima dilakukan pemasangan kabel dan juga dilakukan *jacking* pada *pylon*., sebagaimana terlihat pada gambar berikut.



Gambar 7. 3 Tahap ketiga pelaksanaan

d) Tahap Keempat

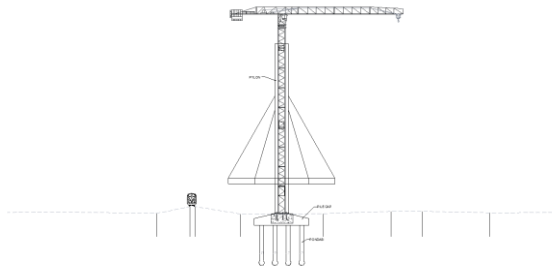
Pada tahap keempat dipasang dek segmen 2 menggunakan *crane* dikarenakan belum tersedia *space* untuk *lifting frame*, selain itu kondisi di lapangan memungkinkan untuk dilakukan demikian. Hal ini diilustrasikan dalam gambar berikut.



Gambar 7. 4 Tahap keempat pelaksanaan

e) Tahap Kelima

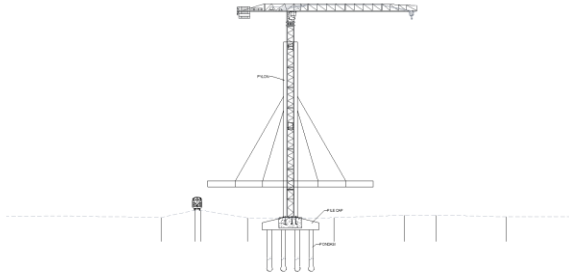
Pada tahap kelima dilakukan pemasangan kabel dan juga dilakukan *jacking* pada *pylon*., sebagaimana terlihat pada gambar berikut.



Gambar 7. 5 Tahap kelima pelaksanaan

f) Tahap Keenam

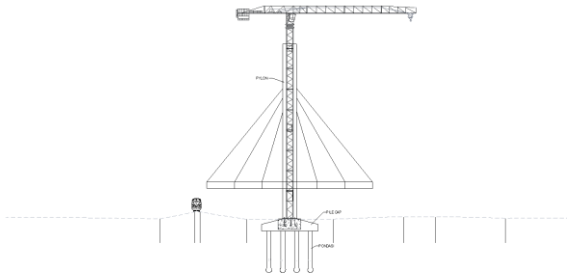
Pada tahap keenam dek dipasang menggunakan *crane* di atas *pylon*., sebagaimana terlihat pada gambar berikut.



Gambar 7. 6 Tahap keenam pelaksanaan

g) Tahap Ketujuh

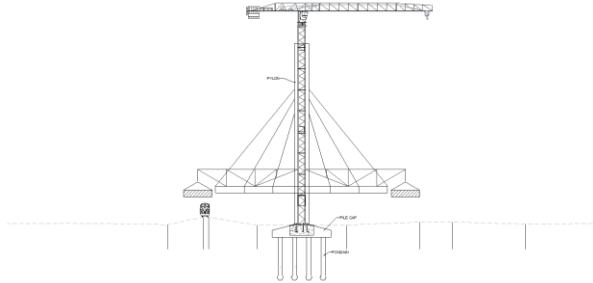
Pada tahap kelima dilakukan pemasangan kabel dan juga dilakukan *jacking* pada *pylon.*, sebagaimana terlihat pada gambar berikut.



Gambar 7. 7 Tahap ketujuh pelaksanaan

h) Tahap Kedelapan

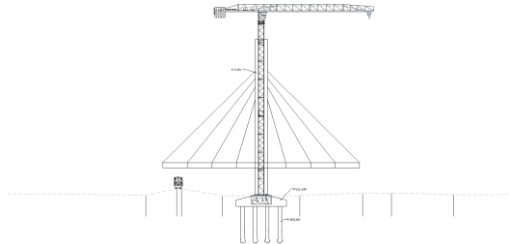
Pada tahap kedelapan ini mulai digunakan form traveler untuk memasang dek, sebagaimana terlihat pada gambar.



Gambar 7. 8 Tahap kedelapan pelaksanaan

i) Tahap Kesembilan

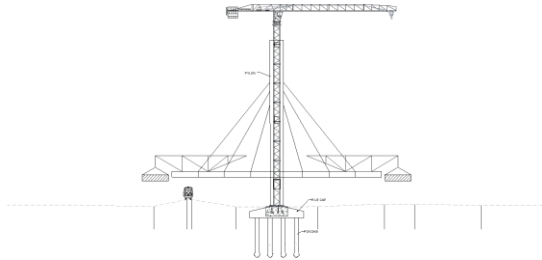
Pada tahap kelima dilakukan pemasangan kabel dan juga dilakukan *jacking* pada *pylon*. Pada tahap ini perancah bisa dilepas dan dipindah untuk pemasangan selanjutnya. Hal ini diilustrasikan pada gambar berikut.



Gambar 7. 9 Tahap kesembilan pelaksanaan

j) Tahap Kesepuluh

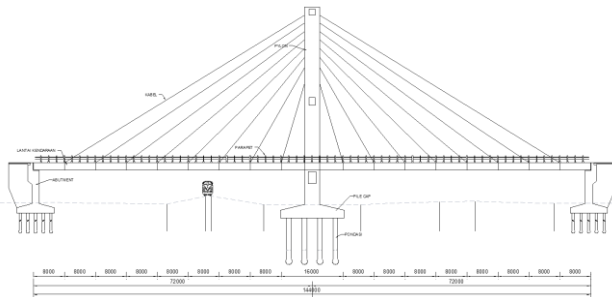
Segmen-segmen dek terus dipasang sesuai dengan metode pada tahap kedelapan hingga segmen dek mencapai ujung jembatan.



Gambar 7. 10 Tahap kesepuluh pelaksanaan

k) Tahap Kesebelas

Setelah semua dek terpasang kemudian pada ujung box girder diberi beban masing-masing seberat 80 kN yang berguna untuk membuat jembatan lurus kembali setelah dilakukan stressing yang membuat dek menjadi naik.



Gambar 7. 11 Tahap kesebelas pelaksanaan

7.2 Analisa Struktur Tahap Pelaksanaan

Ketika pelaksanaan berlangsung, perlu dilakukan analisa kapasitas struktur jembatan. Hal ini dikarenakan pada tahap pelaksanaan berpotensi untuk terjadi beban yang berlebih dibandingkan beban layan jembatan.

Untuk melakukan analisa tersebut digunakan menu *construction stage analysis* pada program bantu MIDAS Civil. *Construction stage analysis* meruapakan salah satu menu utama yang ditawarkan dalam penggunaan MIDAS Civil. Metode dari *construction stage* yang digunakan adalah *backward analysis*, di mana analisa dimulai pada kondisi utuh jembatan yang sudah

sepenuhnya terbangun, kemudian komponen-komponen struktur dilepas satu persatu hingga pada kondisi tahap awal pelaksanaan.

Beban-beban yang diperhitungkan dalam *construction stage analysis* adalah berat sendiri struktur yang secara otomatis akan dihitung oleh MIDAS Civil, *pretension load* untuk kabel, dan beban pelaksanaan yang meliputi *lifting frame* dan pekerja. Beban-beban yang diinputkan kedalam MIDAS Civil sudah dibahas didalam bab permodelan.

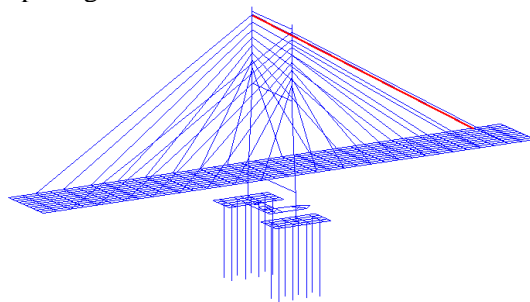
Setelah beban diinputkan, dilakukan konfigurasi tahap-tahap pelaksanaan dan running program. Berikut diberikan hasil analisa struktur, dengan perbandingan beban maksimum pada tahap pelaksanaan dengan kapasitas elemen struktur. Berikut adalah hasil *output box girder* saat *construction stage*.

Tabel 7. 1 Kapasitas box girder

No.	Gaya	Gaya	Kapasitas	Ket
1	Aksial (kN)	7424.89	114250.9386	memenuhi
2	Geser X (kN)	633.13	30553.2	memenuhi
3	Geser Y (kN)	2723.82	39409.2	memenuhi
4	Momen X (kNm)	11526.99	96777.261	memenuhi
5	Momen Y (kNm)	2184.63	82406.925	memenuhi

7.3 Analisa Struktur Ketika *Maintenance*

Pada masa perawatan apabila dibutuhkan penggantian kabel, maka struktur perlu ditinjau kapasitasnya dengan kondisi satu kabel dilepas dan tidak ada beban hidup yang bekerja seperti ditunjukkan pada gambar.



Gambar 7. 12 kabel dilepas pada tahap maintenance

Berikut hasil analisa struktur box girder pemodelan dengan analisa satu kabel dilepas dan dibandingkan dengan kapasitas elemen struktur sebagaimana telah dihitung pada bab-bab sebelumnya.

Tabel 7. 2 Kapasitas box girder

No.	Gaya	Gaya	Kapasitas	Ket
1	Aksial (kN)	6465.03	114250.9	memenuhi
2	Geser X (kN)	397.99	30553.2	memenuhi
3	Geser Y (kN)	1595.63	39409.2	memenuhi
4	Momen X (kNm)	10737.24	96777.26	memenuhi
5	Momen Y (kNm)	1561.54	82406.93	memenuhi

BAB VIII

KESIMPULAN DAN SARAN

8.1 Kesimpulan

Dari hasil analisa dan kontrol yang telah dilakukan dalam mendesain jembatan *cable stayed*, maka dapat diringkaskan hasil tugas akhir yang disajikan sebagai berikut :

1. Jembatan yang memiliki panjang total 144 m yang dimana *pylon* berada di tengah bentang dengan lebar jembatan 20,5 m.
2. Tiang sandaran menggunakan beton dengan dimensi 200x200 dan ketinggian 1,5 m, sedangkan pipa sandaran berupa profil *hollow* dengan dimensi diameter 3” atau 76,2 mm.
3. Pelat lantai kendaraan yang berupa pelat beton bertulang dengan *steeldeck*, tebal 250 mm. Dengan tulangan lentur daerah lapangan menggunakan LYSAGHT BONDEK® dengan ketebalan 0,9 mm dan tulangan lentur daerah tumpuan D16-120. Dengan tulangan bagi D13-150.
4. Gelagar memanjang komposit berupa berupa profil H 400.200.9.12. Sambungan gelagar memanjang dengan gelagar melintang berupa sambungan baut dengan diameter Ø20 berjumlah 4 buah, jumlah stud 80 baris dengan 2 buah stud per baris.
5. Gelagar memanjang berupa berupa profil H 1200.400.16.38. Sambungan gelagar memanjang dengan gelagar utama atau box girder berupa las dengan ketebalan $a = 1.38$ cm dan sambungan gelagar melintang dengan gelagar utama dengan jarak 275 cm berupa sambungan baut dengan diameter Ø36, jumlah stud sebanyak 260 buah dengan 2 buah stud per baris.
6. Analisa metode pelaksanaan atau *staging analysis* menggunakan program MIDAS CIVIL berupa *balanced cantilever* dengan menggunakan *form traveler* untuk

menaikkan lantai kendaraan. *Staging analysis* menggunakan metode *backward solution*.

7. Gelagar utama berupa rectangular twin box girder 1900.1500.60.60 dengan pengaku 200.20. Sambungan antar gelagar utama menggunakan sambungan baut dengan diameter Ø36 pada sekiling gelagar utama.
8. Ditengah *pylon* diberi damping dan yang digunakan untuk desain jembatan ini adalah tipe Lead Rubber Bearing (LRB). Digunakan produk Mageba LASTO LRB dengan diameter 800 mm.
9. Stabilitas aerodinamis jembatan menunjukkan frekuensi alami lentur (f_B) = 0,86 Hz dan torsi (f_T) = 0,39 Hz; efek *vortex-shedding* masuk kategori dalam zona A (*acceptable*) pada grafik klasifikasi efek psikologis berdasarkan amplitude dan zona A (*acceptable*) pada grafik klasifikasi efek psikologis berdasarkan percepatan dan hasil grafik yang diperoleh untuk efek *flutter* sesuai dengan grafik dari efek ayunan dengan beda fase $\pi/2$. efek *flutter* yang menghasilkan $V_{kritis\ aktual} = 47\text{ m/dt} > V_{rencana} = 46\text{ m/dt}$ yang artinya tidak terjadi efek *flutter*.
10. Kabel menggunakan VSL SSI 2000 7-wire strand, tipe ASTM A 416-05 Grade 270 dengan jumlah strand bervariasi mulai dari 31, 22, 19 dan 12 untaian *strand*.
11. Anker pada *deck* dan *pylon* menggunakan *stay cable system SSI 2000*
12. Struktur *pylon* terdiri dari beberapa bagian antara lain :
 - *Section A-A* berupa kolom *pylon* 2 x 4 m dengan tulangan terpasang 124D32 (1,27%) dengan tulangan sengkang 3D16-200 untuk arah x dan 5D16-200 untuk arah y.
 - *Section B-B* berupa balok pengaku 2 x 3 m yang berada di bawah. Dipasang tulangan 100D29 (1,08%) dengan tulangan geser 3D16-200 untuk arah x dan 4D16-200 untuk arah y.

- *Section C-C* berupa kolom *pylon* 4 x 2 m yang berada di atas tempat *stressing*. Dipasang tulangan 124D32 (1,61%) dengan tulangan geser 3D16-200 untuk arah x dan 5D16-200 untuk arah y.
 - *Section D-D* berupa balok pengaku 1,5 x 1,5 m yang berada di atas. Dipasang tulangan 60D25 (1,36%) dengan tulangan geser 2D16-150 untuk arah x dan 2D16-150 arah y.
13. Struktur *pile cap* menggunakan tulangan D36-100 untuk tulangan arah vertical maupun tulangan horizontal.
 14. Analisa tahap *maintenance*, yaitu ketika dilakukan penggantian kabel, dihitung menggunakan program bantu MIDAS Civil dengan asumsi satu kabel lepas. Dan dari analisa, struktur dinyatakan aman.

8.2 Saran

Dari hasil pengerjaan aporan tugas akhir ini masih terdapat kekurangan, maka dari itu untuk hasil yang lebih baik lagi perlu adanya hal hal yang harus diperhatikan saat merencanakan desain yang sejenis menjadi lebih baik, antara lain sebagai berikut ini:

1. Agar ketelitian dalam desain lebih baik dari desain ini, kedepannya perlu untuk meninjau atau menambahkan konfigurasi pembebanan (berupa beban statik) untuk mengantisipasi mendapatkan keadaan yang paling kritis sehingga desain bisa lebih aman saat konfigurasi tersebut.
2. Untuk menentukan distribusi pembebanan pada saat *staging analysis* tepatnya saat pembebanan *form traveler* terhadap lantai kendaraan supaya ditinjau kembali agar dapat mendekati kondisi yang sebenarnya saat pelaksanaan terjadi.

Untuk desain dalam analisa aerodinamis yang diakibatkan oleh beban angin selain dilakukan kontrol menggunakan rumus empiris juga perlu dimodelkan pada terowongan angin. Maksud tersebut untuk bertujuan desain lebih akurat.

(halaman ini sengaja dikosongkan)

DAFTAR PUSTAKA

- Gimsing, J. N., & Geogakis, C. T. (2012). *Cable Supported Bridge Concept and Design Third Edition*. Denmark: John Wiley and Sons Ltd.
- nakazawa, K., & Ir Suyono Sasrodarsono. (2000). *Mekanika Tanah dan Teknik Pondasi*. Jakarta: PT. Pertja.
- Parke, Gerard, & Hewson, N. (2008). *ICE Manual of Bridge Engineering Socond Edition*. London: Thomas Telford Ltd.
- Peraturan Kementerian Pekerjaan Umum Nomor 08/SE/M/2015 tentang "Perencanaan Jembatan Beruji Kabel"*. (2015).
- RSNI T 12 2004 tentang "Perencanaan Struktur Beton untuk Jembatan"*. (2004).
- RSNIT-03-2005 Perencanaan stuktur baja untuk jembatan*. (2005).
- SNI 1725 2016 tentang "Pembebanan untuk Jembatan"*. (2016).
- SNI 2833 2016 tentang "Perancangan Jembatan terhadap Beban Gempa"*. (2016).
- Troitsky, M. (1988). *Cable Stayed Bridges: Theory and Design - Second Edition*. Boston: BSP Professional Books.
- Walther, R. (1999). *Cable Stayed Bridges*. London: Thomas Telford.

(halaman ini sengaja dikosongkan)

LAMPIRAN



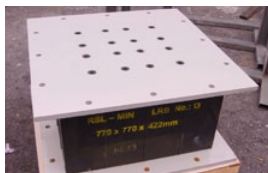
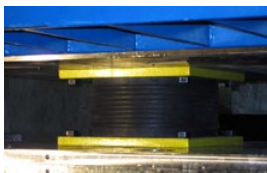
Seismic protection

mageba seismic protection devices – for reliable preservation of structures



LASTO® LRB Lead Rubber Bearing

proven, safe, versatile



mageba
Switzerland www.mageba.ch



Product features

Principle

mageba LASTO®LRB lead rubber bearings work on the principle of base isolation and limits the energy transferred from the ground to the structure in the event of an earthquake. The rubber and steel laminated bearing is designed to support the weight of the structure and to provide post-yield elasticity. The rubber provides the isolation and re-centring of the bearing after a seismic event. The lead core deforms plastically under shear deformations, while dissipating energy through heat.

Properties

LASTO®LRB lead rubber bearings consist of alternate layers of elastomeric material and vulcanized reinforcement steel plates with a central lead core. They provide a high level of damping of up to 30% due to high absorption capacity of the lead core.

As the reinforcement steel plates are fully embedded in the elastomeric material, they are sealed, and therefore protected against corrosion. The devices are manufactured with the rubber vulcanised to the top and bottom connection plates. The bearings can also be supplied with additional anchor plates, allowing easier replacement of the device in case of maintenance needs.

Application

LASTO®LRB devices are made from natural rubber (NR) providing a high resistance against mechanical wear.

Lead rubber bearings find wide applications in structures. This is due to their simplicity and the combined isolation and energy dissipation functions in a single, compact unit. In terms of seismic protection, it is a crucial aspect to minimise the seismic energy transfer to the superstructure and to limit the horizontal displacements of the device.

Under normal conditions LASTO®LRB lead rubber bearings act as regular elastomeric bearings. Therefore, in case of structures

with limited space for bearings and seismic protection means all these functions can be combined in a single device.

The fitting of structures with lead rubber bearings is one of the most used seismic isolation means and has proven its effectiveness in numerous earthquakes. The system has been researched over the past decades and allows the structural engineer a straight-forward simulation of the device response due to simple bi-linear modelling.

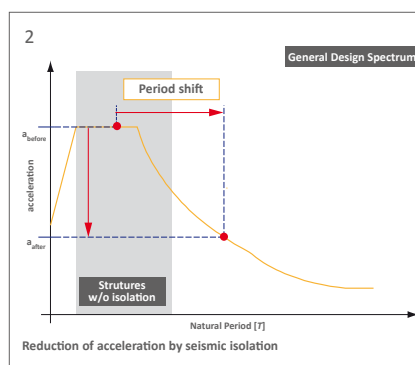
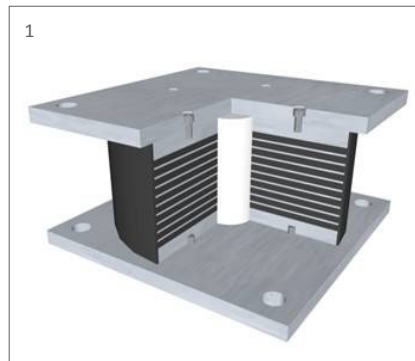
Seismic isolation

Seismic isolation is the decoupling of structures from ground motions induced by earthquake motions which could cause damage to the structures. To achieve such decoupling, different seismic devices – so called isolators – are strategically installed in specific locations of structures, allowing them to perform properly during an earthquake.

Seismic isolators provide sufficient flexibility to the structure, so that the natural period of the structure differentiates as much as possible from the natural period of the earthquake. This prevents the occurrence of resonance, which could lead to severe damage or even collapse of a structure.

An effective seismic isolation system shall provide the following main functions:

- Performance under all service loads, vertical and horizontal; shall be as effective as conventional structural bearings
- Provide enough horizontal flexibility in order to reach the target natural period for the isolated structure
- Re-centring capabilities after the occurrence of a severe earthquake so that no residual displacements can disrupt the serviceability of the structure
- Provide an adequate level of energy dissipation in order to control the displacements that could otherwise damage other structural members



- 1 Schematic view of a LASTO®LRB device
- 2 Principle of seismic isolation – reduction of acceleration by means of period shifting
- 3 LASTO®LRB device ready for installation
- 4 Viaduct de Chillon, Switzerland, retrofitted with LASTO®LRB bearings

Properties & benefits

Materials

The following materials are used for the production of mageba LASTO®LRB lead rubber bearings:

- Reinforcing plates, the top and bottom plates are made from rolled carbon steel conforming to ASTM A36 or A570
- Natural rubber, type NR, grade 3 per ASTM D4014-81
- Lead with a minimum purity of 99.9%

Anchoring system

LASTO®LRB devices are equipped with anchor plates to facilitate the connection to the lower and upper concrete structures. Alternatively, the bearings can be prepared for connection to steel structures.

Corrosion protection

mageba proposes standard corrosion protection systems according to EN ISO 12944, with corrosivity category depending on location, environmental conditions and the required degree of protection.

Corrosion protection systems according to other standards can be provided upon request.

Main dimensions

The table below summarizes the main dimensions for one given seismic design displacement. Values for other sets of input parameters can be provided upon request.

Benefits

- Significant dissipation of energy during earthquakes leading to an optimized structure size and reduced structure cost
- Combined transfer of service and seismic loads leading to minimal space requirement for the devices
- Effective solution for a wide range of types of structures
- Effective solution for the retrofitting or upgrade of existing structures
- Re-centring capabilities of bearings after a seismic event allows to maintain the serviceability of the structure
- Well researched technology with several decades of track record for many applications worldwide

Inspection and maintenance

LASTO®LRB lead rubber bearings are maintenance free. The condition and position of the bearings should be inspected at regular intervals. Upon request, mageba specialists can carry out such inspections and summarize the results in a detailed report.



1 Testing of LASTO®LRB bearings
2 Manufacturing of LASTO®LRB bearings

LASTO®LRB – $d_{bd} = 400\text{mm}$										
D (mm)	t_e (mm)	H_B (mm)	N_{Sd} (kN)	N_{Ed} (kN)	F_1 (kN)	F_2 (kN)	K_r (kN/mm)	K_{eff} (kN/mm)	K_v (kN/mm)	ξ (%)
500	160	326	3,600	1,250	315	755	1.1	1.89	814	29
600	176	350	5,950	2,150	420	990	1.45	2.49	1,346	28
700	192	374	8,750	3,450	515	1230	1.8	3.09	1,991	28
800	208	398	10,950	5,100	620	1500	2.17	3.73	2,725	26
900	216	410	16,250	6,750	690	1750	2.65	4.38	3,658	26
1000	224	422	18,750	10,100	760	2030	3.16	5.07	4,693	25

Important Note: This table is intended only as a preliminary reference for the design of the isolator. The final design and technical details will be fully defined once all the parameters of the project are considered in the final design.

Legend

d_{bd}	Design seismic displacement	F_1	Yield force
D	Rubber block diameter	F_2	Maximum horizontal force (at d_{bd})
t_e	Total rubber height	K_r	Horizontal stiffness
H_B	Total isolator's height	K_{eff}	Effective stiffness
N_{Sd}	Maximum vertical service load	K_v	Vertical stiffness
N_{Ed}	Maximum vertical seismic load	ξ	Damping ratio



Seismic protection

Quality & support

Quality

For five decades, mageba bearings have proven their worth in thousands of structures under most demanding conditions. In addition to the product properties, the extensive experience of mageba's well-qualified manufacturing and installation staff also contributes to the high quality and durability of the products.

mageba has a process-orientated quality system that is certified in accordance with ISO 9001:2008. Quality is also regularly inspected by independent institutes, such as the materials testing body (MPA) of the University of Stuttgart. mageba factories are certified for welding in accordance with ISO 3834-2, and according to the current steel construction standard EN 1090.

CE Certification

LASTO®LRB lead rubber bearings are designed and manufactured in accordance with European Standard EN 15129:2009 and with EN 1337. Bearings are marked with the CE mark of conformity, which confirms that they satisfy all requirements of this standard, without exception. All necessary type testing performed on LASTO®LRB devices was carried out at an independent testing facility and fully supervised by a certified body.

mageba LASTO®LRB lead rubber bearings can also be designed and manufactured in accordance with other international specifications, such as the "AASHTO Guide Specification for Seismic Isolation Design", Japanese Specifications, National Norms, etc.

Testing

If required by the client, full-scale factory production control testing can be carried out. mageba performs the tests in-house as well as with independent 3rd party test institutes. Commonly performed tests are based on European Standard EN 15129:2009 or AASHTO "Guide Specifications for Seismic Isolation Design". For special projects, customised testing can also be performed if requested by the client.

Customer support

Our product specialists will be glad to advise you in selection of the optimal solution for your project, and to provide you with a quotation.

On our website, www.mageba.ch, you can find further product information, including reference lists and tender documentation.

Reference projects for mageba seismic devices



Awaza Bridge (TM)



Flendruz (CH)



Langenargen (DE)



Ramstore Bridge (KZ)



Agin Bridge (TR)



Vasco da Gama Bridge (PT)

mageba seismic devices



RESTON®SA & STU



RESTON®PSD



RESTON®PENDULUM



LASTO®LRB & HDRB

mageba
Switzerland www.mageba.ch

engineering connections®

BONDEK[®] STRUCTURAL STEEL DECKING

DESIGN AND CONSTRUCTION GUIDE
FOR BUILDING PROFESSIONALS

LYSAGHT



PREFACE

Lysaght presents this new publication on LYSAGHT BONDEK®. We upgraded this document and design and construction information for the latest standards and construction practices.

- AS 3600:2009
- AS/NZS 1170.0:2002
- Simplified uniform arrangement for mesh and bars

Our newest release of supporting software and the Design and Construction Manual for BONDEK® Structural Steel Decking incorporates Lysaght's latest research and development work. Improved design and testing methods have again pushed BONDEK® Structural Steel Decking to the forefront. New formwork tables are optimised for steel frame construction but are also suitable for concrete frame construction and masonry walls. Call Steel Direct on 1800 641 417 to obtain additional copies of the Design and Construction Manual and Users Guide for BONDEK® Design Software. The software can be downloaded by visiting:

www.lysaght.com/bondekdesignsoftware

The following is an overview of this manual. It is structured to convey the subject in a comprehensive manner. This manual consists of eight sections. Section 1 presents the general introduction of the BONDEK® and is followed by purpose and scope in Section 2. Formwork design in Section 3 discusses the concept of designing BONDEK® as a formwork. Section 4 presents the concept of designing BONDEK® as a composite floor slab while Section 5 discusses design of composite slab in fire. Design tables for steel framed construction are presented in Section 6. Construction and detailing issues are presented in Section 7. Relevant list of references are presented in Section 8. Finally, material specifications are documented in Appendix A.

We recommend using this manual's tables for typical design cases. If the appropriate table is not in this manual, try the BONDEK® design software, and BONDEK® design software user's guide, which are available separately through Steel Direct or contact your local technical representative.

These developments allow you to make significant improvements compared with the design methods we previously published for slabs using BONDEK®.

CONDITIONS OF USE

This publication contains technical information on the following base metal thicknesses (BMT) of BONDEK®:

- 0.6mm thickness
- 0.75mm thickness
- 0.9mm thickness (Availability subject to enquiry)
- 1.0mm thickness

WARRANTIES

Our products are engineered to perform according to our specifications only if they are installed according to the recommendations in this manual and our publications. Naturally, if a published warranty is offered for the product, the warranty requires specifiers and installers to exercise due care in how the products are applied and installed and are subject to final use and proper installation. Owners need to maintain the finished work.

WARNING

Design capacities presented in this Manual and LYSAGHT® software are based on test results. They shall not be applicable to any similar products that may be substituted for BONDEK®. The researched and tested design capacities only apply for the yield stress and ductility of DECKFORM® steel strip supplied by BlueScope Steel and manufactured by Lysaght to the BONDEK® profile specifications.

For public safety only BONDEK® can be certified to comply with Australian, International standards and the Building Code of Australia in accordance with the product application, technical and specification provisions documented in this Design and Construction Manual.

TECHNICAL SUPPORT

Contact Steel Direct on 1800 641 417 or your local LYSAGHT® Technical Sales Representative to provide additional information.

Contents

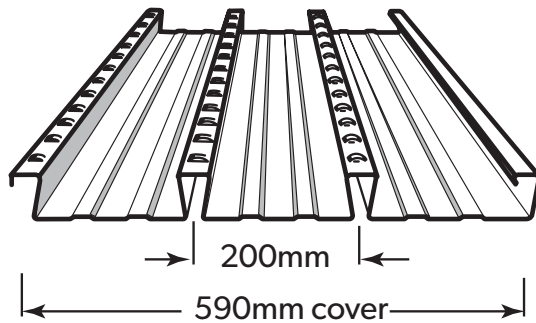
1.0	Introducing BONDEK®	4	7.3.6	Installing BONDEK® on brick supports	35
2.0	Purpose and scope of this publication	6	7.3.7	Installing BONDEK® on concrete frames	36
3.0	Formwork design	7	7.3.8	Provision of construction and movement joints	36
3.1	Introduction	7	7.3.9	Fastening side-lap joints	36
3.2	Recommended deflection limits	7	7.3.10	Cutting and fitting Edgeform	36
3.3	Loads for design	7	7.3.11	Cutting of sheeting	37
3.4	Use of spanning tables	7	7.3.12	Items embedded in slabs	37
3.5	BONDEK® maximum slab spans	9	7.3.13	Holes in sheeting	38
4.0	Composite slab design	14	7.3.14	Sealing	38
4.1	Introduction	14	7.3.15	Inspection	38
4.2	Design loads	14	7.4	Positioning and support of reinforcement	39
4.2.1	Strength load combinations	14	7.4.1	Transverse reinforcement	39
4.2.2	Serviceability load combinations	14	7.4.2	Longitudinal reinforcement	39
4.2.3	Superimposed dead load	14	7.4.3	Trimmers	39
4.3	Design for strength	14	7.5	Concrete	40
4.3.1	Negative bending regions	14	7.5.1	Specification	40
4.3.2	Positive bending regions	14	7.5.2	Concrete additives	40
4.4	Design for durability and serviceability	14	7.5.3	Preparation of sheeting	40
4.4.1	Exposure classification and cover	14	7.5.4	Construction joints	40
4.4.2	Deflections	14	7.5.5	Placement of concrete	40
4.4.3	Crack control	14	7.5.6	Curing	40
4.5	Detailing of conventional reinforcement	15	7.5.7	Prop removal	40
4.6	Use of tables given in Section 6	16	7.6	Finishing	41
5.0	Design for fire	17	7.6.1	Soffit and Edgeform finishes	41
5.1	Introduction	17	7.6.2	Painting	41
5.2	Fire resistance periods	17	7.6.3	Plastering	41
5.3	Design for insulation and integrity	17	7.6.4	Addition of fire protective coating	41
5.4	Design for structural adequacy	17	7.7	Suspended ceilings and services	42
5.4.1	Design loads	17	7.7.1	Plasterboard	42
5.4.2	Design for strength	17	7.7.2	Suspended ceiling	42
5.5	Reinforcement for fire design	17	7.7.3	Suspended services	42
6.0	Design tables - steel-framed construction	19	7.8	Fire stopping detailing	42
6.1	Use of design tables	19	7.8.1	At reinforced block walls	42
6.2	Interpretation of table solutions	20	7.8.2	Fire collars	42
6.3	Single span tables	21	7.9	BONDEK® in post tensioned concrete framed construction	43
6.4	Interior span tables	23	7.9.1	BONDEK® PT clip (post tensioned)	43
6.5	End span tables	28	7.9.2	BONDEK® rib removal at PT anchor points or stressing pans	43
7.0	Construction and detailing	33	7.9.3	Positioning of PT duct/cables in transverse direction	43
7.1	Safety	33	7.10	Architectural matters	44
7.2	Care and storage before installation	33	7.11	Accessories	45
7.3	Installation of BONDEK® sheeting on-site	33	8.0	References	46
7.3.1	Propping	33	Appendix A: Material specifications		47
7.3.2	Laying	34			
7.3.3	Interlocking of sheets	34			
7.3.4	Securing the sheeting platform	34			
7.3.5	Installing BONDEK® on steel frames	34			

BONDEK® STRUCTURAL STEEL DECKING

1. Introducing BONDEK®

Figure 1.1

BONDEK® profile.



BONDEK® is a highly efficient, versatile and robust formwork, reinforcement and ceiling system for concrete slabs. It is a profile steel sheeting widely accepted by the building and construction industry to offer efficiency and speed of construction.

New design rules have been developed for the design of BONDEK® acting as structural formwork for the construction of composite and non-composite slabs (where BONDEK® is used as lost formwork). The rules for calculating moment capacities are based on testing performed at LYSAGHT® Research & Technology facility at Minchinbury.

The data obtained allowed us to include moment capacities in negative regions based on partial plastic design model. As a consequence, the span limits that previously applied to BONDEK® have been increased by up to 8%.

The typical BONDEK® profile and dimension of a cross section of composite slab is given in Figure 1.1 and 1.2 respectively. The section properties and the material specifications are given in Table 1.1 and 1.2 respectively.

BONDEK® is roll-formed from hot dipped, zinc coated, high tensile steel. The steel conforms to AS 1397, grade G550 with Z350 and Z450 coatings.

BONDEK® has superior spanning capacities. 1.0mm BMT BONDEK® can be used as a permanent formwork spanning up to 3.6m unpropped used in steel-framed construction. BONDEK® provides efficient reinforcement in slab construction for steel-framed buildings, concrete framed buildings and in buildings with masonry load bearing walls. The excellent shear bond resistance developed between BONDEK® ribs and concrete enables highly efficient composite action to be achieved in a composite BONDEK® slab.

BONDEK® composites slabs can be designed to achieve a fire-resistance of up to 240 minutes. For fire resistance levels of 90 and 120 minutes, the BONDEK® ribs contribute significantly to the resistance of the slab in fire.

Composite slabs incorporating BONDEK® can be designed in a number of ways:

- Using the design tables given in this manual.
- Calculate from first principles using the relevant Australian Standards, Eurocodes and data from the current BONDEK® design software.
- Contact Steel Direct on 1800 641 417 or your local LYSAGHT® Technical Sales Representative to provide additional information.

However, if in doubt you should get advice from a specialist where required.

DESIGN ADVANTAGES INCLUDE:

- Excellent spanning capacities for greater strength and less deflection.
- Acts as permanent formwork with minimal propping and no stripping of formwork face is required.
- Fast and easy to install (590mm wide) with less handling required.
- Works as reinforcement with composite slab saving on concrete and reinforcement costs.
- Ribs at 200mm centres creating a safe working platform with slip resistant embossments on the ribs.
- Advanced design for fire resistance.
- New BONDEK® design software gives added flexibility and ease of design.
- Backed by a BlueScope Steel warranty.
- Nationwide technical support.

Figure 1.2

BONDEK® dimensions (2 sheets shown),
(Fire reinforcement is not shown, see Chapter 5).

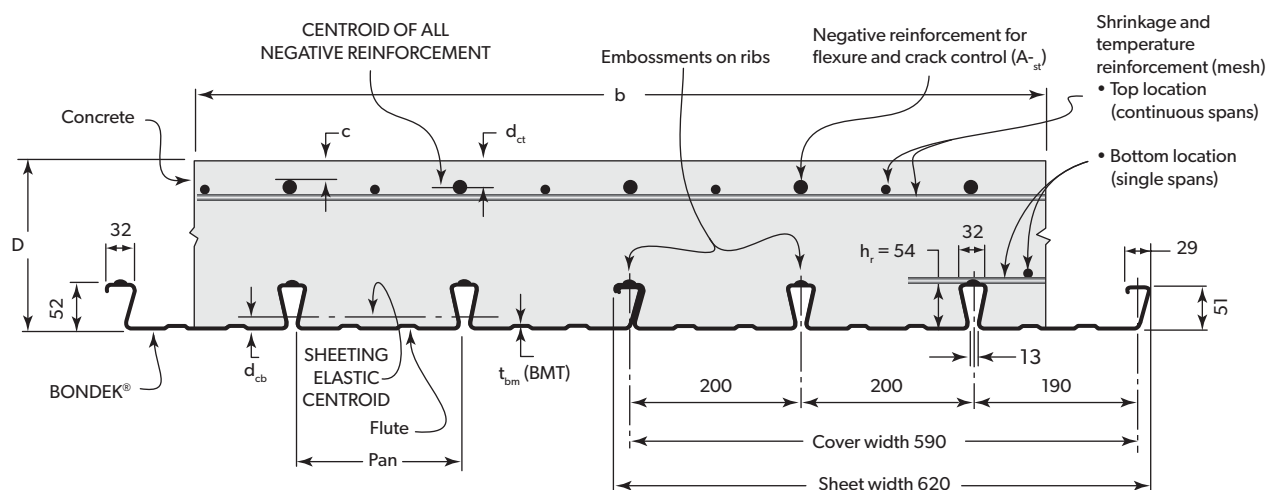


Table 1.1

BONDEK® section properties.

	Thickness BMT	Cross-sectional area of BONDEK®	Sheeting elastic centroid
	mm	A_{sh} mm ² /m	d_{cb} mm
BONDEK®	1.0	1678	15.5
	0.9	1503	15.4
	0.75	1259	15.3
	0.6	1007	15.2

Table 1.2

Material specification (based on Z350).

Thickness	Mass		Yield Strength	Coverage
mm	kg/m ²	kg/m	MPa	m ² /t
0.60	8.52	5.03	550	117.31
0.75	10.50	6.20	550	95.24
0.90	12.48	7.36	550	80.16
1.00	13.79	8.14	550	72.50

2. Purpose and scope of this publication

As stated in the Preface and Introduction, the purpose of this Manual is to facilitate the design of BONDEK® in its use as formwork (with and without propping) and within concrete slabs for both steel-framed and concrete framed buildings. It has been developed in accordance with the latest Australian Standards. The Manual includes the following information:

- Formwork Design and Spanning Tables (Section 3)
- Composite Slab Design (Section 4)
- Design for Fire (Section 5)
- Design Tables - Steel-framed construction (Section 6)
- Construction and Detailing (Section 7)

Section 6 gives tabulated solutions for composite slabs in typical design situations.

Use this Manual's tables for typical design cases. If the appropriate table is not in this Manual, try the BONDEK® design software, which is available from the website, at: www.lysaght.com/bondekdesignsoftware, to assist in designing other cases. If none of these options provides a suitable solution, contact Steel Direct on 1800 641 417 or your local LYSAGHT® Technical Sales Representative to provide additional information.

The information presented by the tabulated solutions of Sections 3 and 6 is intended for guidance only. This information is to be used only in conjunction with a consulting structural engineer.

3. Formwork design

3.1 INTRODUCTION

The installation of BONDEK® follows traditional methods for quick and easy installation. It is available in long lengths so large areas can be quickly and easily covered to form a safe working platform during construction. BONDEK® provides a cover width of 590mm, which allows quick installation.

Formwork design calculations are covered in this section-geometric layout considerations are generally covered in Section 7 (Construction and Detailing).

Our design tables may be used to detail BONDEK® acting as structural formwork, provided the following conditions are satisfied.

3.2 RECOMMENDED DEFLECTION LIMITS

AS 3610-1995 Formwork for concrete, defines five classes of surface finish (numbered 1 to 5) covering a broad range of applications.

We recommend a deflection limit of span/240 for the design of composite slabs in which good general alignment is required, so that the soffit has a good visual quality when viewed as a whole. We consider span/240 to be suitable for a Class 3 and 4 surface finish and, in many situations, Class 2. Where alignment affects the thickness of applied finishes (for example vermiculite), you may consider a smaller limit of span/270 to be more suitable.

We consider span/130 to be a reasonable maximum deflection limit appropriate for profile steel sheeting in situations where visual quality is not significant (Class 5).

The design rules presented may be used for deflection limits other than those stated above however, for deflection greater than span/130, you may contact our information service.

3.3 LOADS FOR DESIGN

BONDEK® shall be designed as formwork for two stages of construction according to AS 3610-1995 and AS 2327.1-2003.

STAGE I

Prior to the placement of the concrete:

- during handling and erection of the formwork; and
- once the formwork is erected but prior to the placement of the concrete.

When a live load due to stacked materials can be adequately controlled on the site at less than 4 kPa, the reduced design live load shall be clearly indicated on the formwork documentation. (1 kPa in tables from Section 3.4).

STAGE II

During placement of the concrete up until the concrete has set (until f_{cm} reaches 15 MPa and concrete is able to act flexurally to support additional loads such as stacked materials).

Note: No loads from stacked materials are allowed until the concrete has set.

- Different pattern loading shall be considered, including when one formwork span only is loaded - with live loads, loads due to stacked materials and wet concrete. The BONDEK® has sufficient capacity for a concentrated point load of 2.0 kN for all spans and BMT. It is not necessary to perform formwork capacity checks for concentrated loads.

3.4 USE OF SPANNING TABLES

The spanning tables presented in Section 3.5 are based on the following assumptions and constraints. The reader needs to ensure that the particular situation being designed falls within these assumptions and constraints.

1. These tables can be used for different types of construction (steel-frame, concrete frame, masonry wall supports) provided BONDEK® sheets are securely fixed to all permanent and temporary supports at every span.
 - Suitable secure fixing methods should be used such as spot welds, self drilling screws or drive nails.
 - Temporary props are equally spaced within each slab span.
 - There are two sets of formwork tables:
Ratio of two adjacent slab spans equal 1:1 that is $L/L=1$
The ratio of the longer slab span (L_1) to the shorter slab span (L_2) does not exceed 1.2, that is $L_1/L_2 \leq 1.2$.
2. The tables shall be used for normal density concrete (2400kg/m³).
3. The lines of support shall extend across the full width of the sheeting and have a minimum bearing 50mm at the ends of the sheets and 100mm at intermediate supports over which sheeting is continuous, including at props. 25mm minimum bearing length at the ends of sheets is acceptable in concrete frame construction.
4. The tables are based on the following maximum construction loads:
 - Workmen and equipment = 100kg/m².
 - Mounting of concrete = 300kg/m² over an area of 1.6 x 1.6m and zero over the remainder.
 - Stacking of material on BONDEK® sheets before placement of concrete only = 100kg/m². This load shall be clearly indicated on the formwork documentation and controlled on-site. Use BONDEK® design software for higher loads.
5. Tables developed based on maximum BONDEK® length is 19,500mm. (Check availability of local lengths).
6. No loads from stacked materials are allowed until the concrete has set.
7. The sheets shall not be spliced or jointed.
8. Allowance for the weight of reinforcement as well as the effect of ponding has been taken into account.
9. Supports shall be effectively rigid and strong to support construction loads.
10. The sheeting shall not have cantilever portions.
11. Wet concrete deflection of BONDEK® = $L/240$ or $L/130$, where L is the distance between centres of props or permanent supports.
12. The information contained in the publication is intended for guidance only. This information to be used only in conjunction with a consulting structural engineer.
13. Further details can be sought from the publication BONDEK® Design Manual or contact Steel Direct on 1800 641 417 or your local LYSAGHT® Technical Sales Representative to provide additional information.

Figure 3.1a

BONDEK® formwork for concrete frame.

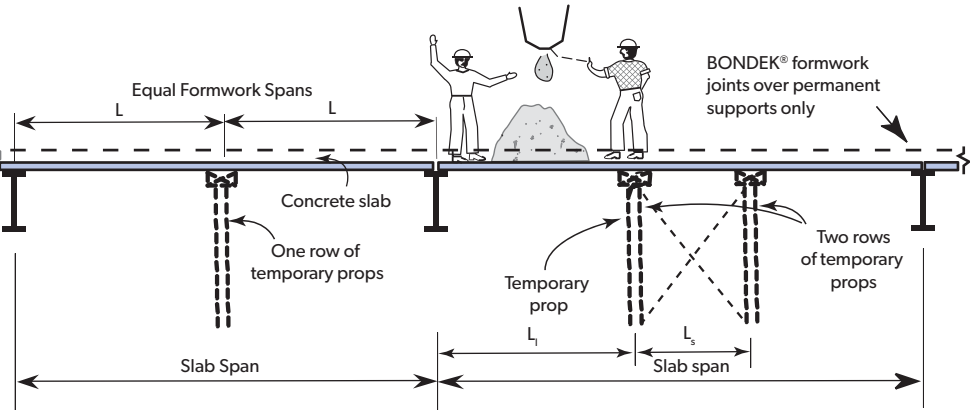


Figure 3.1b

BONDEK® formwork for masonry.

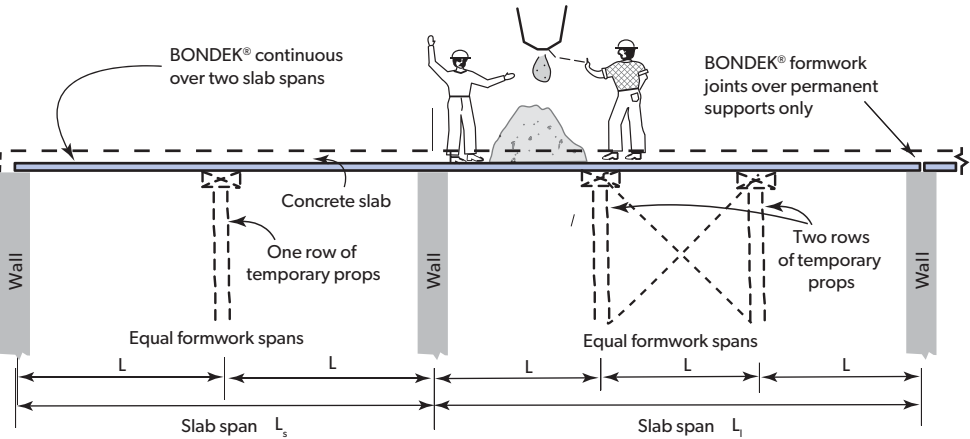
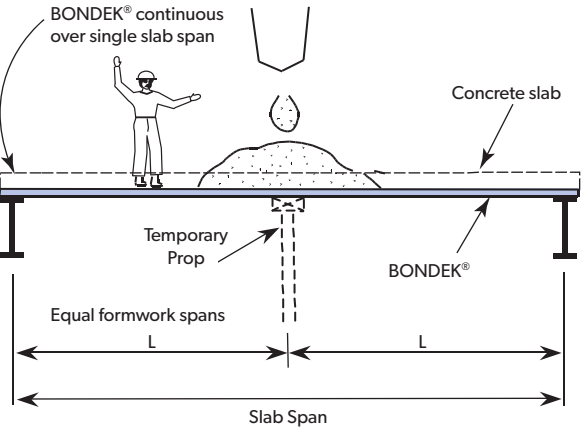


Figure 3.1c

BONDEK® formwork for steel frame.



3.5 BONDEK® MAXIMUM SLAB SPANS

Maximum slab spans, mm

BONDEK® sheets continuous over single slab span

Formwork deflections limits L/240 (Visual appearance important)

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2000	4950	7350	2150	5850	8150	2250	6300	8700	2350	6500	9050
110	1900	4750	7150	2050	5700	7900	2200	6100	8450	2250	6350	8800
120	1800	4650	6900	2000	5550	7700	2150	5950	8250	2200	6150	8550
130	1750	4500	6650	1950	5400	7500	2100	5800	8050	2150	6000	8350
140	1700	4400	6400	1900	5300	7300	2050	5650	7850	2100	5900	8100
150	1650	4300	6200	1850	5200	7100	2000	5550	7600	2050	5750	7900
160	1600	4250	6050	1750	5050	6900	1900	5450	7400	2000	5650	7700
170	1550	4150	5850	1750	5000	6750	1850	5300	7250	1950	5550	7500
180	1550	4050	5700	1700	4900	6550	1850	5200	7050	1900	5400	7350
190	1500	4000	5550	1650	4750	6400	1800	5100	6900	1850	5300	7200
200	1450	3900	5400	1600	4650	6250	1750	5000	6750	1850	5200	7050
210	1400	3850	5300	1550	4550	6150	1700	4900	6600	1800	5050	6900
220	1400	3800	5200	1550	4450	6000	1650	4800	6500	1750	5000	6800
230	1350	3750	5050	1500	4350	5900	1650	4700	6400	1700	4900	6650
240	1350	3700	4950	1500	4300	5800	1600	4600	6250	1700	4800	6550
250	1300	3600	4850	1450	4200	5650	1600	4550	6150	1650	4750	6450


Maximum slab spans, mm

BONDEK® sheets continuous over single slab span

Formwork deflections limits L/130 (Visual appearance not important)

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2100	4800	7200	2550	5900	8850	2700	7100	10000	2800	7700	10000
110	2050	4700	7050	2500	5750	8650	2650	6900	10000	2700	7450	10000
120	2000	4550	6850	2450	5600	8400	2550	6700	9850	2650	7300	10000
130	1950	4450	6700	2350	5450	8200	2500	6550	9650	2600	7100	10000
140	1950	4350	6550	2300	5350	8050	2450	6400	9450	2550	6950	9800
150	1900	4250	6400	2250	5250	7850	2400	6250	9250	2500	6800	9600
160	1850	4200	6300	2200	5100	7700	2350	6100	9100	2450	6650	9450
170	1800	4100	6150	2200	5000	7550	2300	6000	8900	2400	6500	9250
180	1800	4050	6050	2150	4950	7400	2250	5900	8750	2350	6400	9100
190	1750	3950	5950	2100	4850	7250	2250	5750	8650	2300	6250	8950
200	1750	3900	5850	2050	4750	7150	2200	5650	8500	2250	6150	8800
210	1700	3850	5750	2050	4700	7050	2150	5550	8350	2250	6050	8700
220	1700	3750	5650	2000	4600	6900	2150	5500	8250	2200	5950	8550
230	1650	3700	5550	2000	4550	6800	2100	5400	8100	2200	5850	8450
240	1650	3650	5500	1950	4450	6700	2050	5300	7950	2150	5750	8350
250	1600	3600	5400	1900	4400	6600	2050	5250	7850	2100	5650	8200

Notes:

- These are formwork selection tables only. Maximum slab spans in these tables shall be designed by a qualified structural engineer.
- Use BONDEK® design software for support widths other than 100mm.
- 1 kPa Live Load due to stacked materials is used - this shall be indicated on formwork documentation and controlled on-site.
-  The availability of 0.9mm BMT BONDEK® is subject to enquiry.
- Refer to General Engineering Notes when using these tables.

Maximum slab spans, mm

BONDEK® sheets continuous over 2 slab spans

Formwork deflections limits L/240 (Visual appearance important)

Equal slab spans

Slab depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2450	4900	7350	2900	5550	8350	3150	5900	8900	3250	6150	9250
110	2350	4750	7150	2850	5400	8100	3050	5750	8650	3150	5950	8950
120	2300	4650	6950	2750	5250	7850	2950	5600	8400	3050	5800	8750
130	2250	4500	6800	2700	5100	7650	2900	5450	8200	3000	5650	8500
140	2200	4400	6600	2650	5000	7500	2800	5350	8000	2950	5550	8300
150	2150	4250	6400	2600	4850	7300	2750	5200	7800	2850	5400	8100
160	2100	4150	6200	2500	4750	7100	2700	5050	7600	2800	5250	7900
170	2050	4000	6050	2500	4600	6950	2650	4950	7400	2750	5150	7700
180	2000	3900	5900	2450	4500	6750	2600	4800	7250	2700	5000	7550
190	2000	3800	5750	2350	4400	6600	2550	4700	7100	2650	4900	7350
200	1950	3700	5600	2300	4300	6450	2500	4600	6950	2600	4800	7200
210	1900	3650	5450	2250	4200	6300	2450	4500	6800	2500	4700	7100
220	1900	3550	5350	2200	4100	6200	2400	4450	6650	2500	4600	6950
230	1850	3450	5200	2150	4050	6050	2350	4350	6550	2450	4550	6850
240	1800	3400	5100	2150	3950	5950	2300	4300	6450	2400	4450	6700
250	1800	3350	5000	2100	3900	5850	2250	4200	6300	2350	4400	6600

Maximum slab spans, mm


BONDEK® sheets continuous over 2 slab spans

Formwork deflections limits L/130 (Visual appearance not important)

Equal slab spans

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2400	4800	7200	2950	5900	8850	3550	7050	10000	3850	7300	10000
110	2350	4700	7050	2850	5750	8650	3450	6850	10000	3700	7100	10000
120	2250	4550	6850	2800	5600	8400	3350	6700	10000	3650	6950	10000
130	2200	4450	6700	2700	5450	8200	3250	6550	9800	3550	6800	10000
140	2150	4350	6550	2650	5350	8050	3200	6400	9600	3450	6650	10000
150	2100	4250	6400	2600	5250	7850	3100	6250	9400	3400	6550	9800
160	2100	4200	6300	2550	5100	7700	3050	6100	9200	3300	6400	9600
170	2050	4100	6150	2500	5000	7550	3000	6000	9000	3250	6300	9450
180	2000	4050	6050	2450	4950	7440	2950	5900	8850	3200	6200	9300
190	1950	3950	5950	2400	4850	7250	2850	5750	8650	3100	6100	9150
200	1950	3900	5850	2350	4750	7150	2800	5650	8500	3050	6000	9000
210	1900	3850	5750	2350	4700	7050	2750	5550	8350	3000	5900	8850
220	1850	3750	5650	2300	4600	6900	2750	5500	8250	2950	5800	8750
230	1850	3700	5550	2250	4550	6800	2700	5400	8100	2900	5750	8650
240	1800	3650	5500	2200	4450	6700	2650	5300	7950	2850	5650	8500
250	1800	3600	5400	2200	4400	6600	2600	5250	7850	2800	5600	8400

Notes:

- These are formwork selection tables only. Maximum slab spans in these tables shall be designed by a qualified structural engineer.
- Use BONDEK® design software for support widths other than 100mm.
- 1 kPa Live Load due to stacked materials is used - this shall be indicated on formwork documentation and controlled on-site.
-  The availability of 0.9mm BMT BONDEK® is subject to enquiry.
- Refer to General Engineering Notes when using these tables.

Maximum slab spans, mm

BONDEK® sheets continuous over 3 or more slab spans

Formwork deflections limits L/240 (Visual appearance important)

Equal slab spans

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2450	4900	7350	2700	5550	8350	2900	5900	8900	3000	6150	9250
110	2350	4750	7150	2600	5400	8100	2800	5750	8650	2900	5950	8950
120	2300	4650	6950	2550	5250	7850	2750	5600	8400	2850	5800	8750
130	2200	4500	6800	2500	5100	7650	2650	5450	8200	2750	5650	8500
140	2100	4400	6600	2450	5000	7500	2600	5350	8000	2700	5550	8300
150	2050	4250	6400	2350	4850	7300	2500	5200	7800	2600	5400	8100
160	2000	4150	6200	2300	4750	7100	2450	5050	7600	2550	5250	7900
170	1950	4000	6050	2250	4600	6950	2400	4950	7400	2500	5150	7700
180	1900	3900	5900	2150	4500	6750	2350	4800	7250	2450	5000	7550
190	1850	3800	5750	2100	4400	6600	2300	4700	7100	2400	4900	7350
200	1800	3700	5600	2050	4300	6450	2250	4600	6950	2350	4800	7200
210	1750	3650	5450	2050	4200	6300	2200	4500	6800	2300	4700	7100
220	1700	3550	5350	2000	4100	6200	2150	4450	6650	2250	4600	6950
230	1650	3450	5200	1950	4050	6050	2100	4350	6550	2200	4550	6850
240	1650	3400	5100	1900	3950	5950	2050	4300	6450	2150	4450	6700
250	1600	3350	5000	1850	3900	5850	2050	4200	6300	2150	4400	6600

Maximum slab spans, mm


BONDEK® sheets continuous over 3 or more slab spans

Formwork deflections limits L/130 (Visual appearance not important)

Equal slab spans

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2400	4800	7200	2950	5900	8850	3450	7050	10000	3550	7300	10000
110	2350	4700	7050	2850	5750	8650	3350	6850	10000	3500	7100	10000
120	2250	4550	6850	2800	5600	8400	3250	6700	10000	3400	6950	10000
130	2200	4450	6700	2700	5450	8200	3200	6550	9800	3300	6800	10000
140	2150	4350	6550	2650	5350	8050	3150	6400	9600	3250	6650	10000
150	2100	4250	6400	2600	5250	7850	3050	6250	9400	3200	6550	9800
160	2100	4200	6300	2550	5100	7700	3000	6100	9200	3150	6400	9600
170	2050	4100	6150	2500	5000	7550	2950	6000	9000	3050	6300	9450
180	2000	4050	6050	2450	4950	7440	2900	5900	8850	3000	6200	9300
190	1950	3950	5950	2400	4850	7250	2850	5750	8650	2950	6100	9150
200	1950	3900	5850	2350	4750	7150	2800	5650	8500	2900	6000	9000
210	1900	3850	5750	2350	4700	7050	2750	5550	8350	2900	5900	8850
220	1850	3750	5650	2300	4600	6900	2750	5500	8250	2850	5800	8750
230	1850	3700	5550	2250	4550	6800	2700	5400	8100	2800	5750	8650
240	1800	3650	5500	2200	4450	6700	2650	5300	7950	2750	5650	8500
250	1800	3600	5400	2200	4400	6600	2600	5250	7850	2700	5600	8400

Notes:

- These are formwork selection tables only. Maximum slab spans in these tables shall be designed by a qualified structural engineer.
- Use BONDEK® design software for support widths other than 100mm.
- 1 kPa Live Load due to stacked materials is used - this shall be indicated on formwork documentation and controlled on-site.
-  The availability of 0.9mm BMT BONDEK® is subject to enquiry.
- Refer to General Engineering Notes when using these tables.

Maximum slab spans, mm

BONDEK® sheets continuous over 2 slab spans

Formwork deflections limits L/240 (Visual appearance important)

Slabs spans ratio up to 1:1.2

Slab depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2400	4900	7250	2750	5350	8000	2950	5700	8550	3050	5950	8900
110	2350	4650	7000	2700	5200	7800	2850	5550	8300	3000	5750	8650
120	2300	4450	6700	2600	5050	7600	2800	5400	8100	2900	5600	8400
130	2200	4300	6500	2550	4900	7400	2700	5250	7900	2850	5450	8150
140	2150	4150	6250	2500	4750	7150	2650	5100	7650	2750	5300	7950
150	2100	4050	6050	2450	4600	6950	2600	4950	7450	2700	5150	7700
160	2050	3900	5900	2350	4500	6750	2500	4800	7250	2600	5000	7550
170	2000	3800	5700	2300	4350	6550	2450	4700	7050	2550	4900	7350
180	1950	3700	5550	2250	4250	6400	2400	4600	6900	2500	4800	7200
190	1900	3600	5400	2200	4150	6250	2350	4500	6750	2450	4700	7050
200	1850	3500	5300	2150	4050	6100	2300	4400	6600	2400	4600	6900
210	1800	3450	5150	2100	4000	6000	2250	4300	6450	2350	4500	6750
220	1750	3350	5050	2050	3900	5850	2200	4200	6350	2300	4400	6650
230	1750	3300	4950	2000	3800	5750	2150	4150	6250	2250	4350	6500
240	1700	3200	4850	1950	3750	5650	2150	4050	6100	2200	4250	6400
250	1650	3150	4750	1950	3700	5550	2100	4000	6050	2200	4200	6300

Maximum slab spans, mm


BONDEK® sheets continuous over 2 slab spans

Formwork deflections limits L/130 (Visual appearance not important)

Slabs spans ratio up to 1:1.2

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2350	4750	7150	2900	5850	8750	3500	6800	10000	3650	7050	10000
110	2300	4650	6950	2850	5700	8550	3400	6600	9950	3550	6850	10000
120	2250	4500	6800	2750	5550	8350	3300	6450	9700	3450	6700	10000
130	2200	4450	6650	2700	5400	8150	3200	6300	9500	3400	6550	9850
140	2150	4300	6500	2650	5300	7950	3150	6200	9300	3300	6400	9650
150	2100	4250	6350	2600	5200	7800	3100	6050	9100	3250	6300	9450
160	2050	4150	6250	2500	5050	7600	3000	5950	8450	3200	6150	9250
170	2000	4050	6100	2450	4950	7450	2950	5850	8750	3150	6050	9100
180	2000	4000	6000	2450	4900	7350	2900	5750	8600	3100	5950	8950
190	1950	3950	5900	2400	4800	7200	2850	5650	8500	3050	5850	8800
200	1900	3850	5800	2350	4700	7050	2800	5550	8350	3000	5750	8650
210	1900	3800	5700	2300	4650	6950	2750	5450	8200	2950	5700	8550
220	1850	3750	5650	2250	4550	6850	2700	5400	8100	2900	5600	8400
230	1850	3700	5550	2250	4500	6750	2650	5300	8000	2850	5500	8300
240	1800	3650	5450	2200	4400	6650	2600	5250	7850	2850	5450	8150
250	1800	3600	5400	2150	4350	6550	2550	5150	7750	2800	5350	8050

Notes:

- These are formwork selection tables only. Maximum slab spans in these tables shall be designed by a qualified structural engineer.
- Use BONDEK® design software for support widths other than 100mm.
- 1 kPa Live Load due to stacked materials is used - this shall be indicated on formwork documentation and controlled on-site.
-  The availability of 0.9mm BMT BONDEK® is subject to enquiry.
- Refer to General Engineering Notes when using these tables.

Maximum slab spans, mm

BONDEK® sheets continuous over 3 or more slab spans

Formwork deflections limits L/240 (Visual appearance important)

Slabs spans ratio up to 1.1.2

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2350	4900	7250	2600	5350	8000	2800	5700	8550	2900	5950	8900
110	2250	4650	7000	2550	5200	7800	2700	5550	8300	2800	5750	8650
120	2150	4450	6700	2450	5050	7600	2650	5400	8100	2750	5600	8400
130	2100	4300	6500	2400	4900	7400	2550	5250	7900	2650	5450	8150
140	2000	4150	6250	2300	4750	7150	2500	5100	7650	2600	5300	7950
150	1950	4050	6050	2250	4600	6950	2400	4950	7450	2500	5150	7700
160	1900	3900	5900	2200	4500	6750	2350	4800	7250	2450	5000	7550
170	1850	3800	5700	2150	4350	6550	2300	4700	7050	2400	4900	7350
180	1800	3700	5550	2050	4250	6400	2250	4600	6900	2350	4800	7200
190	1750	3600	5400	2000	4150	6250	2200	4500	6750	2300	4700	7050
200	1700	3500	5300	2000	4050	6100	2150	4400	6600	2250	4600	6900
210	1650	3450	5150	1950	4000	6000	2100	4300	6450	2200	4500	6750
220	1650	3350	5050	1900	3900	5850	2050	4200	6350	2150	4400	6650
230	1600	3300	4950	1850	3800	5750	2000	4150	6250	2100	4350	6500
240	1550	3200	4850	1800	3750	5650	2000	4050	6100	2050	4250	6400
250	1550	3150	4750	1800	3700	5550	1950	4000	6050	2050	4200	6300

Maximum slab spans, mm


BONDEK® sheets continuous over 3 or more slab spans

Formwork deflections limits L/130 (Visual appearance not important)

Slabs spans ratio up to 1.1.2

Slab Depth D (mm)	0.6 BMT BONDEK® No of props per span			0.75 BMT BONDEK® No of props per span			0.9 BMT BONDEK® No of props per span			1.0 BMT BONDEK® No of props per span		
	0	1	2	0	1	2	0	1	2	0	1	2
100	2350	4750	7150	2900	5850	8750	3350	6800	10000	3450	7050	10000
110	2300	4650	6950	2850	5700	8550	3250	6600	9950	3350	6850	10000
120	2250	4500	6800	2750	5550	8350	3150	6450	9700	3300	6700	10000
130	2200	4450	6650	2700	5400	8150	3100	6300	9500	3200	6550	9850
140	2150	4300	6500	2650	5300	7950	3050	6200	9300	3150	6400	9650
150	2100	4250	6350	2600	5200	7800	2950	6050	9100	3100	6300	9450
160	2050	4150	6250	2500	5050	7600	2900	5950	8450	3000	6150	9250
170	2000	4050	6100	2450	4950	7450	2850	5850	8750	2950	6050	9100
180	2000	4000	6000	2450	4900	7350	2800	5750	8600	2900	5950	8950
190	1950	3950	5900	2400	4800	7200	2750	5650	8500	2850	5850	8800
200	1900	3850	5800	2350	4700	7050	2700	5550	8350	2850	5750	8650
210	1900	3800	5700	2300	4650	6950	2700	5450	8200	2800	5700	8550
220	1850	3750	5650	2250	4550	6850	2650	5400	8100	2750	5600	8400
230	1850	3700	5550	2250	4500	6750	2600	5300	8000	2700	5500	8300
240	1800	3650	5450	2200	4400	6650	2550	5250	7850	2650	5450	8150
250	1800	3600	5400	2150	4350	6550	2500	5150	7750	2600	5350	8050

Notes:

- These are formwork selection tables only. Maximum slab spans in these tables shall be designed by a qualified structural engineer.
- Use BONDEK® design software for support widths other than 100mm.
- 1 kPa Live Load due to stacked materials is used - this shall be indicated on formwork documentation and controlled on-site.
-  The availability of 0.9mm BMT BONDEK® is subject to enquiry.
- Refer to General Engineering Notes when using these tables.

4. Composite slab design

4.1 INTRODUCTION

Considerable research into the behaviour of composite slabs has been performed in the past years. The efficiency of the composite slab depends on the composite action between the steel sheeting and concrete slab. The experiments indicated that the shear bond strength at the interface between the steel sheet and the surrounding concrete is the key factor in determining the behaviour of composite slabs.

The adhesion bond between the sheeting and the concrete can play a part in this behaviour. However, following the breakdown of the adhesion bond, slip is resisted by mechanical interlock and friction developed between the steel sheeting and the surrounding concrete. The mechanical interlock and friction depend upon the shape of the rib, thickness of the sheet and size and frequency of the embossments.

This chapter explains the parameters upon which our design tables are based. Solutions to your design problems may be obtained by direct reference to the current version of our BONDEK® design software.

The design solutions are based on linear elastic analysis according to AS 3600:2009 Clause 6.2 and partial shear connection theory. Data about composite performance of BONDEK® slabs have been obtained from full-scale slab tests, supplemented by slip-block tests.

Use the appropriate LYSAGHT® design software in other cases (concrete grades, environmental classifications, fire ratings, moment redistribution, etc.).

The tables provide solutions for steel-frame (or other narrow supports like masonry walls) provided the following conditions are satisfied.

4.2 DESIGN LOADS

4.2.1 STRENGTH LOAD COMBINATIONS

For strength calculations, design loads for both propped and unpropped construction shall be based on the following load combinations.

Load combinations and pattern loading shall be considered according to AS 3600:2009 Clause 2.4 including pattern loads according to Clause 2.4.4.

As per AS 3600:2009: $1.2 (G_c + G_{sh} + G_{sdl}) + 1.5 Q$

For bending (composite) and shear capacity in positive (with top outer fibre of concrete in compression) areas as per EN 1994-1-1:2005.

$1.35 (G_c + G_{sh} + G_{sdl}) + 1.5 Q$

where G_c = self weight of concrete; G_{sh} = self weight of sheeting;
 G_{sdl} = superimposed dead load (partitions, floor tiles, etc.)
 Q = live load

4.2.2 SERVICEABILITY LOAD COMBINATIONS

Our load tables are based on deflections due to loading applied to the composite slab according to AS 3600:2009 Clause 2.4 including pattern loads according to Clause 2.4.4. Load combinations for crack control have been worked out in accordance AS 3600:2009 Clause 9.4.1.

4.2.3 SUPERIMPOSED DEAD LOAD

The maximum superimposed dead load (G_{sdl}) assumed in our design tables is 1.0 kPa. Use BONDEK® design software for other G_{sdl} loads.

4.3 DESIGN FOR STRENGTH

4.3.1 NEGATIVE BENDING REGIONS

A) NEGATIVE BENDING STRENGTH

For the bending strength design in negative moment regions, the presence of the sheeting in the slab is ignored and the slab shall be designed as conventional reinforced concrete solid slab. For this purpose, use the provisions of AS 3600:2009, Clause 9.1.

The minimum bending strength requirement of AS 3600:2009, Clause 9.1.1 shall be satisfied.

B) SHEAR STRENGTH

The strength of a slab in shear shall be designed as per the guidelines outlined in Clause 9.2 of AS 3600:2009. The Design tables are based on these guidelines.

4.3.2 POSITIVE BENDING REGIONS

A) POSITIVE BENDING STRENGTH

Positive bending capacity shall be calculated as per EN 1994-1-1:2005 Clause 9.7.2. It takes into consideration partial shear connection theory and the design tables have been developed in accordance with it.

B) SHEAR STRENGTH

The positive shear capacity can be calculated as per EN 1992-1-1:2004 Clause 4.3.2.3. Partial shear connection theory is used for the contribution of BONDEK®.

4.4 DESIGN FOR DURABILITY AND SERVICEABILITY

4.4.1 EXPOSURE CLASSIFICATION AND COVER

The exposure classification used in design tables for BONDEK® slabs is A1 as defined in AS 3600:2009, Clause 4.3. Use BONDEK® software for all other classifications.

The minimum concrete cover (c) to reinforcing steel, measured from the slab top face, shall comply with AS 3600:2009, Table 4.10.3.2.

4.4.2 DEFLECTIONS

Deflections are calculated using method given in AS 3600:2009 Clause 8.5.3.

4.4.3 CRACK CONTROL

The Design tables have been developed based on advanced requirements for crack control as per Clause 9.4.1 of AS 3600:2009. It is important to use minimum bar diameters in negative areas to minimise total depth of reinforcement. Bar diameters 16mm and 20mm cannot be used with these tables. It is recommended that the small reinforcing bars be suitably distributed over the negative moment region not exceeding the spacing requirement as specified in AS 3600:2009 Clause 9.4.1. Use BONDEK® design software to design slabs with bars other than 12mm.

4.5 DETAILING OF CONVENTIONAL REINFORCEMENT

Conventional tensile reinforcement in negative moment regions must be detailed in accordance with relevant requirements for one way slabs.

PATTERN 1

Negative-moment regions must be designed to satisfy the requirements of AS 3600:2009 Clause 9. The composite slab

negative-moment regions can be treated as solid reinforced-concrete sections.

PATTERN 2

When live loads exceed twice the dead load, at least one third of negative reinforcement must continue over a whole span.

Figure 4.1

Pattern 1 for conventional reinforcement.

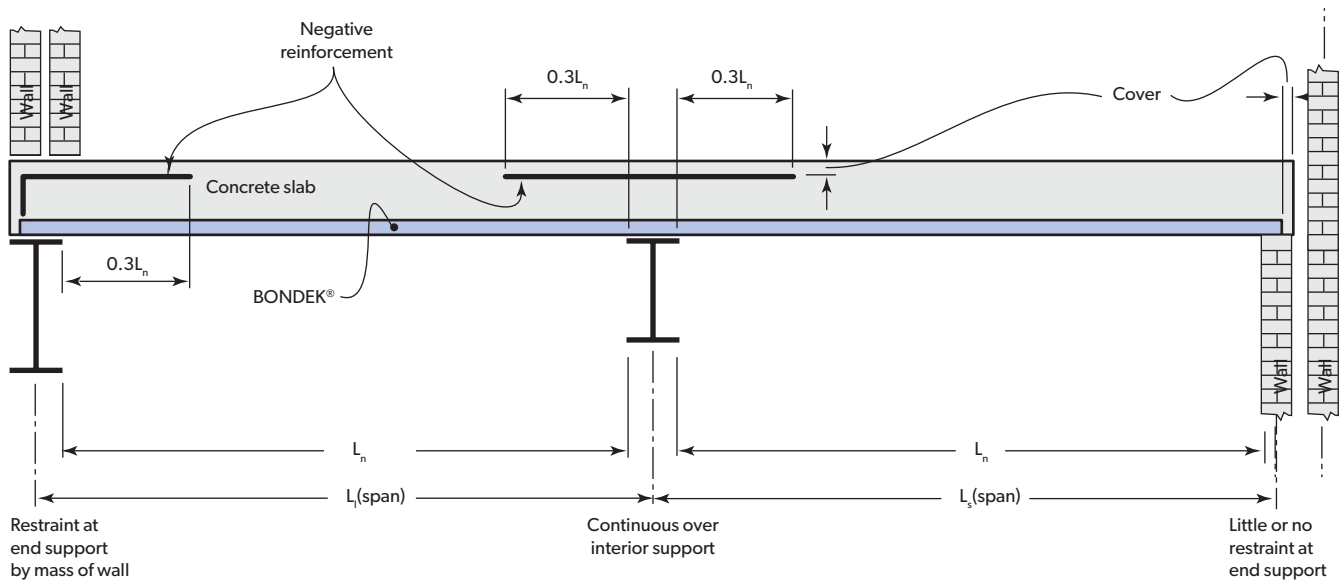
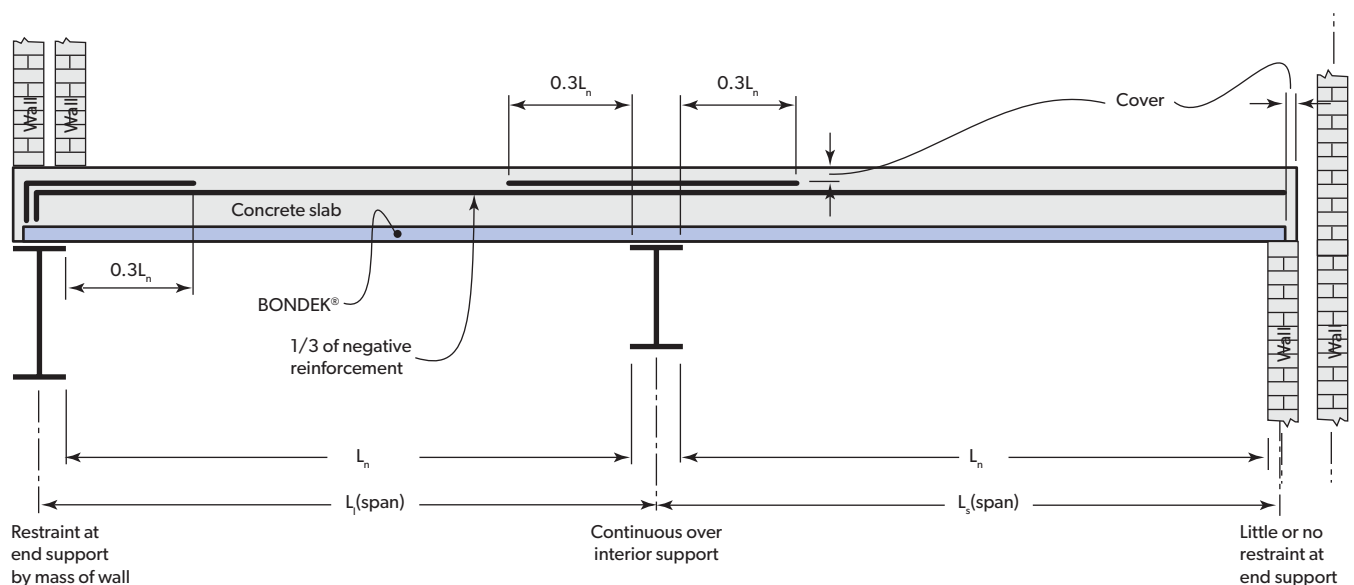


Figure 4.2

Pattern 2 for conventional reinforcement when imposed load exceeds twice the dead load.



4.6 USE OF TABLES GIVEN IN SECTION 6

The design solutions given in the tables presented in Section 6 is based on the design principles given in this section and the following assumptions and constraints. Other constraints are stated in Section 6.1. The reader needs to ensure that the particular situation being designed falls within these assumptions and constraints.

1. The concrete manufacture and materials satisfy the requirements of AS 3600:2009, Clause 17.
2. The lines of support extend across the full width of the sheeting and have a minimum bearing of 50mm at the ends of the sheets, and 100mm minimum at intermediate supports over which sheeting is continuous.
3. The ratio of the longer slab span (L_l) to the shorter slab span (L_s) of any two adjacent spans does not exceed 1.2, that is $L_l / L_s \leq 1.2$.
4. The slab has a uniform cross-section.
5. The design loads for serviceability and strength design must be uniformly-distributed and static in nature.
6. The bending moments at the supports are only caused by the action of vertical loads applied to the slab.
7. The geometry of the steel sheeting profile must conform to the dimensions and tolerances shown on our production drawings. Sheeting with embossments less than the specified lower characteristic value shall not be used compositely unless the value of longitudinal shear resistance is revised.
8. Material and construction requirements for conventional reinforcing steel shall be in accordance with AS 3600:2009, Clause 17.2 and the design yield stress, (f_{sy}), shall be taken from AS 3600:2009, Table 3.2.1, for the appropriate type and grade of reinforcement, and manufacturers' data.
9. BONDEK® shall not be spliced, lapped or joined longitudinally in any way.
10. The permanent support lines shall extend across the full width of the slab.
11. Similar to the requirement in AS 2327.1, Clause 4.2.3, composite action shall be assumed to exist between the steel sheeting and the concrete once the concrete in the slab has attained a compressive strength of 15 MPa, that is $f'_{cj} \geq 15$ MPa. Prior to the development of composite action during construction (Stage 4 defined in AS 2327.1), potential damage to the shear connection shall be avoided; and no loads from stacked materials are allowed.
12. Detailing of conventional tensile reinforcement over negative moment regions shall be arranged in accordance with the Figures 4.1 and 4.2. Refer to AS 3600:2009, Clause 9.1.3 for more information on detailing of tensile reinforcement in one-way slab.
13. Only BONDEK® profiles can be used with this manual. High design value of longitudinal shear strength of composite slab, $\tau_{u,Rd}$, responsible for composite performance are achieved due to the advanced features of BONDEK®.

5. Design for fire

5.1 INTRODUCTION

During the design of composite floor slabs exposed to fire, it is essential to take into account the effect of elevated temperatures on the material properties. The composite slabs should be assessed with respect to structural adequacy, thermal insulation and integrity. The minimum required thickness of composite slab to satisfy the insulation and integrity criterion is presented in Section 5.3. Design of slabs for the structural adequacy is presented in Section 5.4.

This Section discusses the parameters relating to the exposure of the soffit to fire, upon which our design tables are based. Solutions to your design problems may be obtained by direct reference to either our design tables, or our BONDEK® design software. Software will give more economical results. BONDEK® composite slabs are designed based on AS 3600:2009 Clause 5.3.1b and EN 1994.1.2:2005 Clause 4.4 supplemented with test data and thermal response modelling.

Our fire design tables may be used to detail BONDEK® composite slabs when the soffit is exposed to fire provided the following conditions are satisfied:

1. The composite slab acts as a one-way element spanning in the direction of the sheeting ribs for both room temperature and fire conditions.
2. The fire design load is essentially uniformly distributed and static in nature.
3. Transverse reinforcement for the control of cracking due to shrinkage and temperature effects is provided.
4. Adequate detailing of slab jointing, edges, slab holes and cavities (for penetrating, embedded or encased services) to provide the appropriate fire resistance period. Alternatively the local provision of suitable protection (such as fire spray material) will be necessary.
5. Reinforcement conforms to Section 5.5 of this manual.

5.2 FIRE RESISTANCE PERIODS

Five fire cases, 60, 90, 120, 180 and 240 minutes, are considered. In each fire case the fire resistance periods for structural adequacy, integrity and insulation are taken to be equal duration. Fire resistance period up to two hours are provided in the design tables. It is recommended to use BONDEK® design software for fire resistance period up to four hours and alternative locations for fire reinforcement.

5.3 DESIGN FOR INSULATION AND INTEGRITY

Minimum required overall depth, D of BONDEK® slabs for insulation and integrity for various fire resistance periods is given in Table 5.1.

5.4. DESIGN FOR STRUCTURAL ADEQUACY

5.4.1 DESIGN LOADS

Use AS/NZS 1170.0:2002, Clause 4.2.4, together with design load for fire, $W_f = 1.0G + \psi Q$.

5.4.2 DESIGN FOR STRENGTH

In any specific design of a composite floor slab exposed to fire, it is essential the strength reduction factors account for the adverse effect of elevated temperatures on the mechanical properties of concrete and steel as well as a strength of shear bond capacity. The strength and structural adequacy must be checked in all

potentially critical cross-sections for the given period of fire exposure considering the strength reduction factors. Fire tests on composite slabs incorporating BONDEK® profiled steel sheeting have been conducted at the Centre for Environmental Safety and Risk Engineering, the Victoria University of Technology.

The tests have been used to validate the finite element analysis result for temperatures of the slab for different fire periods. Subsequent tests were performed to evaluate shear bond capacities of BONDEK® profiled sheeting during fire.

Test results revealed that shear bond capacity in fire (composite action) is the governing parameter. Composite performance is the critical parameter during fire, therefore the location of the embossments is crucial. As the embossments are located on top of ribs, BONDEK® has superior composite performance during fire. BONDEK® ribs or part of the ribs are sufficiently cool to act as effective fire reinforcement.

No additional fire reinforcement is normally necessary for typical BONDEK® composite slabs with fire resistance up to 90 minutes. Small amounts fire reinforcement may be necessary for 120 minutes fire resistance.

Table 5.1

Fire resistance period	Normal density concrete
Minutes	D (mm)
60	90
90	100
120	120
180	140
240	175

5.5 REINFORCEMENT FOR FIRE DESIGN

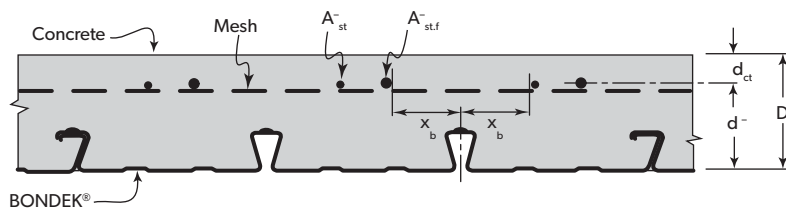
The arrangement of additional fire reinforcement for fire design is shown in Figure 5.1.

- Some additional reinforcement may be necessary in some rare cases, in addition to any mesh and negative reinforcement required by our tables for composite slab design.
- D500L reinforcement is ignored in our design tables as fire reinforcement at all locations where significant elongation of reinforcement is expected
- The location of reinforcement $A_{st,f}^-$ for Fire detail 1 is in a single top layer at a depth of d_{ct} below the slab top face (refer to Figure 5.1). This detail is applicable to continuous slabs only, this option is used for interior spans in our design tables.
- The location of reinforcement $A_{st,f}^+$ for Fire detail 2 is in a single bottom layer at a distance of y_b above the slab soffit (refer to Figure 5.1). This option is used for single spans and end spans of continuous slabs in our design tables.
- The cross-sectional area of the additional reinforcement for fire design is designated $A_{st,f}^+$ in our tables (D500N with bar diameter = 12mm or less).
- The negative reinforcement (A_{st}^-) and the additional fire reinforcement ($A_{st,f}^+$ or $A_{st,f}^-$ as applicable), shall be located as shown in Figure 5.1 and 5.2.
- Location of mesh is at bottom for single spans and top for continuous spans. (See also Figure 1.2).

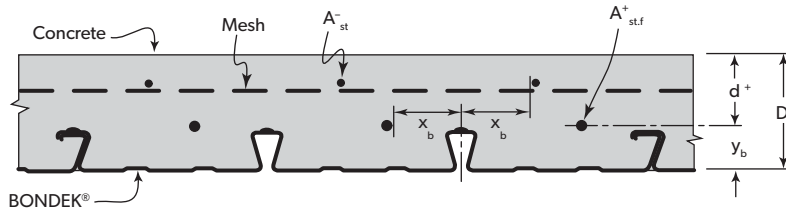
Figure 5.1

Details of reinforcement for fire design.

Fire detail 1



Fire detail 2



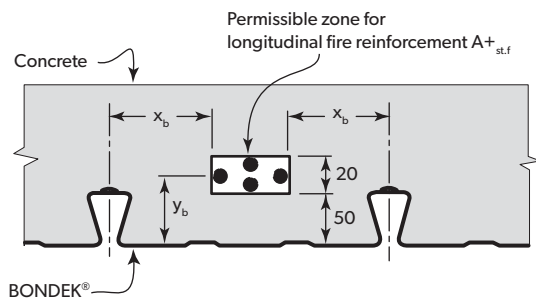
The longitudinal bars which make up $A^+_{st.f}$ should be located within the zone shown in Figure 5.2.

$x_b = 85\text{mm}$ minimum

$y_b = 60\text{mm}$ average

Figure 5.2

Permissible zone for location of longitudinal fire reinforcement for Fire Detail 2.



Notes:

1. Fire option 1 (Top location of additional fire reinforcement) is used in design tables for interior spans.
Fire option 2 (Bottom) is used in design tables for simple and end spans.
2. Recommended bottom location of fire reinforcement is chosen for practical reasons (to place fire bars on transverse bars laid on top of BONDEK® ribs). Lower location of fire bars with cover down to 20mm from soffit may give more economical results - please consult LYSAGHT® Research & Technology. Design tables are based on location as shown above in Figure 5.2.

6. Design tables - steel-framed construction

6.1 USE OF DESIGN TABLES

The design parameters specific for each table are given in the tables:

- Spans: single, continuous, end or interior
- Spans: centre-to-centre (L)
- Thickness of the slab (D)
- Characteristic imposed 'live' load (Q)

The rest of parameters are common for all tables and listed below:

- More than four spans for continuous spans
- Concrete grade: $f_c^l = 32$ MPa
- Type of construction: steel-frame construction or equivalent
- Density of wet concrete: 2400kg/m³
- BONDEK® used as a structural deck with thickness 0.6, 0.75, 0.9 or 1.0mm BMT (0.9mm available subject to enquiry)
- Minimum 100mm width of permanent supports
- A1 exposure classification (20mm cover for negative reinforcement)
- Composite slab deflection limits: L/250 for total loads and L/500 for incremental deflection
- Crack control required
- 1 kPa of superimposed dead load (G_{sdl}) in addition to self weight
- Reinforcement D500N for negative and fire reinforcement with maximum 12mm bar diameter
- Location of negative reinforcement as shown on Figure 1.2
- Location of fire reinforcement as shown on Figure 6.1 and 6.2
- Shrinkage mesh as in the Table 6.1 for minor degree of crack control
- Formwork with at least one temporary support per span assumed (fully supported conditions)

Notes:

Slab is designed for unit width (1.0m width)

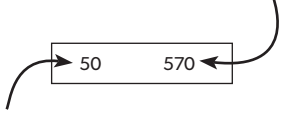
Negative and fire reinforcement shown in tables is in addition to shrinkage mesh specified in Table 6.1. If negative fire reinforcement is required, at least one bar per BONDEK® rib should be placed. Smaller bar diameter may result in less negative and fire reinforcement.

$\psi_s=0.7$, $\psi_l=0.4$

6.2 INTERPRETATION OF TABLE SOLUTIONS

KEY - Single Spans

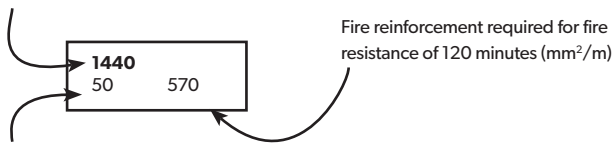
Fire reinforcement required for fire resistance of 120 minutes (mm²/m)



Bottom reinforcement required for fire resistance of 60 minutes (mm²/m)

KEY - Continuous Spans

Top tensile (negative) reinforcements over supports (mm²/m)



Fire reinforcement required for fire resistance of 90 minutes (mm²/m)

Notes:

- 1. Areas without cells mean that a design solution is not possible based on input parameters and design options presented in this manual. Contact LYSAGHT® Research & Technology for further options.
- 2. Single spans do not require top tensile reinforcement, relevant cells are not shown.
- 3. All spans are centre-to-centre.
- 4. A dash (-) means no fire reinforcement is necessary.
- 5. N/A means a design solution with this particular fire rating is not possible.
- 6. Top tensile/negative reinforcement is additional to shrinkage mesh area.

Table 6.1

Mesh sizes to be used with design tables.

Depth	Mesh
100	SL62
120	SL62
140	SL72
160	SL82
180	SL82

Figure 6.1

BONDEK® for single spans.

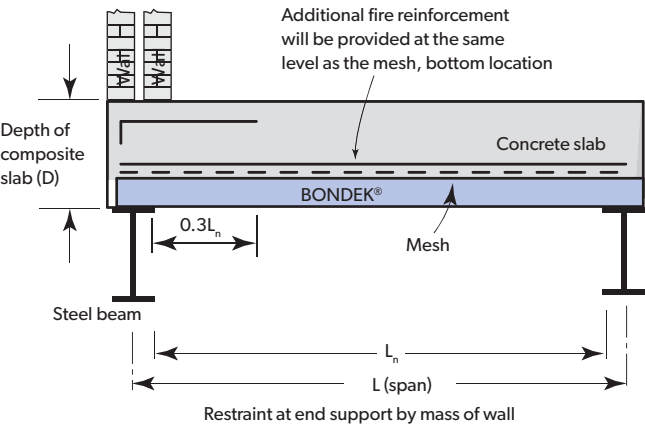
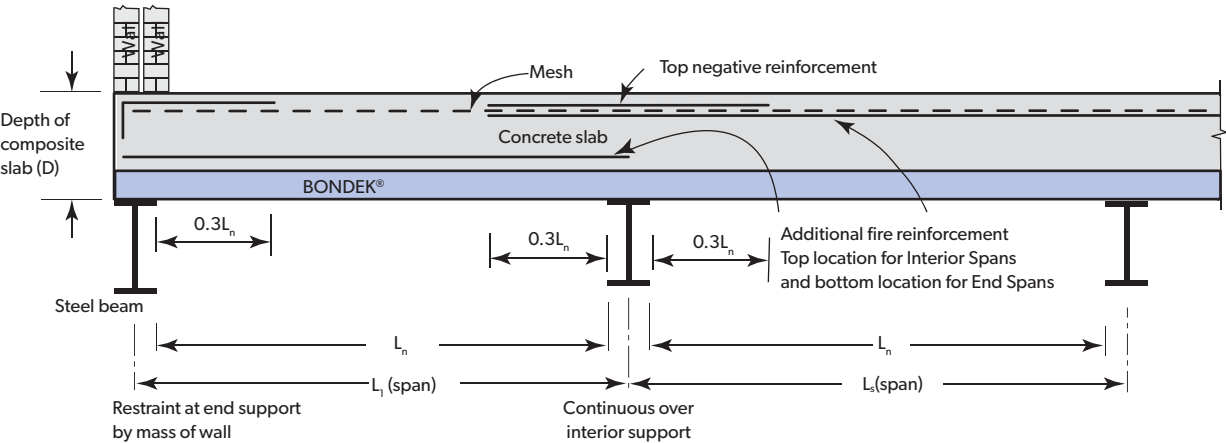


Figure 6.2

BONDEK® continuous spans.



Note: 1/3 top negative reinforcement shall continue all over the span if ratio of live load to total dead load is more than 2.

6.3 SINGLE SPAN TABLES

Single Spans 100mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1400	- N/A	- N/A	- N/A	- N/A	- N/A
1600	- N/A	- N/A	- N/A	- N/A	- N/A
1800	- N/A	- N/A	- N/A	- N/A	- N/A
2000	- N/A	- N/A	- N/A	- N/A	- N/A
2200	- N/A	- N/A	- N/A	- N/A	40 N/A
2400	- N/A	- N/A	- N/A	40 N/A	140 N/A
2600	- N/A	20 N/A	70 N/A	130 N/A	
2800	50 N/A	100 N/A	150 N/A		
3000	130 N/A				
3200					

Single Spans 120mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1800	- -	- -	- -	- -	- -
2000	- -	- -	- -	- -	- 20
2200	- -	- -	- -	- 30	- 80
2400	- -	- 30	- 50	- 90	- 150
2600	- 50	- 80	- 110	- 150	- 220
2800	- 100	- 130	- 170	- 220	60 300
3000	- 160	- 190	- 230	50 290	
3200	- 220	30 260	60 300		
3400	40 280	80 330			
3600	100 350				
3800					

Single Spans 140mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
2200	- -	- -	- -	- -	- -
2400	- -	- -	- -	- -	- 10
2600	- -	- -	- -	- 20	- 70
2800	- -	- 10	- 40	- 70	- 130
3000	- 30	- 60	- 90	- 120	- 190
3200	- 80	- 110	- 140	- 180	20 260
3400	- 130	- 160	- 200	10 250	
3600	- 180	- 220	20 260		
3800	10 240	40 280			
4000	60 300				
4200					

Single Spans 160mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
2400	- -	- -	- -	- -	- -
2600	- -	- -	- -	- -	- -
2800	- -	- -	- -	- -	- 10
3000	- -	- -	- -	- 10	- 60
3200	- -	- -	- 20	- 60	- 110
3400	- 20	- 40	- 70	- 110	- 180
3600	- 60	- 90	- 120	- 170	- 240
3800	- 110	- 140	- 180	- 230	
4000	- 160	- 200	- 240		
4200	- 220	20 260			
4400	20 260				
4600					

Single Spans 180mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
3000	- -	- -	- -	- -	- 10
3200	- -	- -	- -	- 10	- 50
3400	- -	- -	- 20	- 50	- 110
3600	- 20	- 40	- 70	- 100	- 160
3800	- 60	- 90	- 110	- 150	- 220
4000	- 110	- 140	- 170	- 210	
4200	- 140	- 180	- 210	20 260	
4400	- 190	- 230	20 260		
4600	- 240	40 280			
4800	50 300				
5000					

6.4 INTERIOR SPAN TABLES

Interior Spans 100mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1400	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
1600	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
1800	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
2000	170	170	170	170	210
	- N/A	- N/A	- N/A	- N/A	- N/A
2200	170	170	170	180	290
	- N/A	- N/A	- N/A	- N/A	- N/A
2400	170	170	170	240	380
	- N/A	- N/A	- N/A	- N/A	- N/A
2600	170	170	210	310	470
	- N/A	- N/A	- N/A	- N/A	- N/A
2800	170	170	270	380	580
	- N/A	- N/A	- N/A	- N/A	- N/A
3000	170	200	330	470	700
	- N/A	- N/A	- N/A	- N/A	- N/A
3200	180	250	400	560	830
	- N/A	- N/A	- N/A	- N/A	- N/A
3400	220	310	480	660	980
	- N/A	- N/A	- N/A	- N/A	- N/A
3600	260	360	560	770	
	- N/A	- N/A	- N/A	- N/A	
3800	310	420	650	890	
	- N/A	- N/A	- N/A	- N/A	
4000	370	490	750		
	- N/A	- N/A	- N/A		
4200	420	560			
	- N/A	- N/A			
4400	470				
	- N/A				
4600	530				
	- N/A				
4800					

Interior Spans 120mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1600	210	210	210	210	210
	- -	- -	- -	- -	- -
1800	210	210	210	210	210
	- -	- -	- -	- -	- -
2000	210	210	210	210	210
	- -	- -	- -	- -	- -
2200	210	210	210	210	210
	- -	- -	- -	- -	- -
2400	210	210	210	210	270
	- -	- -	- -	- -	- -
2600	210	210	210	220	340
	- -	- -	- -	- -	- -
2800	210	210	210	280	430
	- -	- -	- -	- -	- -
3000	210	210	250	340	510
	- -	- -	- -	- -	- -
3200	210	210	300	410	610
	- -	- -	- -	- -	- -
3400	210	230	360	490	720
	- -	- -	- -	- -	- -
3600	210	280	420	570	830
	- -	- -	- -	- -	- -
3800	240	330	490	660	960
	- -	- -	- -	- -	- -
4000	290	380	570	760	1100
	- -	- -	- -	- -	- -
4200	330	440	640	860	
	- -	- -	- -	- -	
4400	370	490	720	960	
	- -	- -	- -	- -	
4600	420	550	810		
	- -	- -	- -		
4800	480	620	900		
	- -	- -	- -		
5000	530	690			
	- -	- -			
5200	590				
	- -				
5400					

Interior Spans 140mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1800	210	210	210	210	210
	- -	- -	- -	- -	- -
2000	210	210	210	210	210
	- -	- -	- -	- -	- -
2200	210	210	210	210	210
	- -	- -	- -	- -	- -
2400	210	210	210	210	210
	- -	- -	- -	- -	- -
2600	210	210	210	210	230
	- -	- -	- -	- -	- -
2800	210	210	210	210	300
	- -	- -	- -	- -	- -
3000	210	210	210	230	370
	- -	- -	- -	- -	- -
3200	210	210	210	290	450
	- -	- -	- -	- -	- -
3400	210	210	250	350	530
	- -	- -	- -	- -	- -
3600	210	210	300	420	620
	- -	- -	- -	- -	- -
3800	210	230	360	490	720
	- -	- -	- -	- -	- -
4000	210	280	420	570	830
	- -	- -	- -	- -	- -
4200	240	320	490	650	940
	- -	- -	- -	- -	- -
4400	270	370	550	730	1060
	- -	- -	- -	- -	- -
4600	320	420	620	830	1190
	- -	- -	- -	- -	- -
4800	360	480	700	930	
	- -	- -	- -	- -	
5000	410	540	780	1030	
	- -	- -	- -	- -	
5200	460	600	870		
	- -	- -	- -		
5400	520	660	960		
	- -	- -	- -		
5600	580	730			
	- -	- -			
5800	640				
	- -				
6000	700				
	- -				

Interior Spans 160mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
2000	200	200	200	200	200
	- -	- -	- -	- -	- -
2200	200	200	200	200	200
	- -	- -	- -	- -	- -
2400	200	200	200	200	200
	- -	- -	- -	- -	- -
2600	200	200	200	200	200
	- -	- -	- -	- -	- -
2800	200	200	200	200	200
	- -	- -	- -	- -	- -
3000	200	200	200	200	250
	- -	- -	- -	- -	- -
3200	200	200	200	200	310
	- -	- -	- -	- -	- -
3400	200	200	200	240	390
	- -	- -	- -	- -	- -
3600	200	200	200	300	460
	- -	- -	- -	- -	- -
3800	200	200	200	360	550
	- -	- -	- -	- -	- -
4000	200	200	250	430	640
	- -	- -	- -	- -	- -
4200	200	220	290	490	730
	- -	- -	- -	- -	- -
4400	200	260	340	570	830
	- -	- -	- -	- -	- -
4600	230	310	400	640	930
	- -	- -	- -	- -	- -
4800	270	360	450	730	1050
	- -	- -	- -	- -	- -
5000	310	410	520	810	1170
	- -	- -	- -	- -	- -
5200	360	470	580	910	1300
	- -	- -	- -	- -	- -
5400	410	530	650	1010	
	- -	- -	- -	- -	
5600	460	590	720	1110	
	- -	- -	- -	- -	
5800	510	650	790	1430	
	- -	- -	- -	- 10	
6000	570	720	870		
	- -	- -	- -		

Interior Spans 180mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	$Q=1.5 G_{sdl}=1$	$Q=2.5 G_{sdl}=1$	$Q=3.5 G_{sdl}=1$	$Q=5.0 G_{sdl}=1$	$Q=7.5 G_{sdl}=1$
2000	250	250	250	250	250
	- -	- -	- -	- -	- -
2200	250	250	250	250	250
	- -	- -	- -	- -	- -
2400	250	250	250	250	250
	- -	- -	- -	- -	- -
2600	250	250	250	250	250
	- -	- -	- -	- -	- -
2800	250	250	250	250	250
	- -	- -	- -	- -	- -
3000	250	250	250	250	250
	- -	- -	- -	- -	- -
3200	250	250	250	250	250
	- -	- -	- -	- -	- -
3400	250	250	250	250	320
	- -	- -	- -	- -	- -
3600	250	250	250	250	390
	- -	- -	- -	- -	- -
3800	250	250	250	300	460
	- -	- -	- -	- -	- -
4000	250	250	250	360	540
	- -	- -	- -	- -	- -
4200	250	250	250	420	610
	- -	- -	- -	- -	- -
4400	250	250	290	480	700
	- -	- -	- -	- -	- -
4600	250	270	340	550	790
	- -	- -	- -	- -	- -
4800	250	310	390	620	890
	- -	- -	- -	- -	- -
5000	270	360	450	700	990
	- -	- -	- -	- -	- -
5200	310	410	500	780	1100
	- -	- -	- -	- -	- -
5400	360	460	560	860	1220
	- -	- -	- -	- -	- -
5600	410	520	630	950	1340
	- -	- -	- -	- -	- -
5800	450	570	700	1050	1470
	- -	- -	- -	- -	10
6000	510	630	770	1150	
	- -	- -	- -	- -	

6.5 END SPAN TABLES

End Spans 100mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1400	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
1600	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
1800	170	170	170	170	170
	- N/A	- N/A	- N/A	- N/A	- N/A
2000	170	170	170	170	240
	- N/A	- N/A	- N/A	- N/A	- N/A
2200	170	170	170	210	330
	- N/A	- N/A	- N/A	- N/A	- N/A
2400	170	170	190	270	420
	- N/A	- N/A	- N/A	- N/A	- N/A
2600	170	170	250	350	520
	- N/A	- N/A	- N/A	- N/A	- N/A
2800	170	220	310	430	640
	- N/A	- N/A	- N/A	- N/A	- N/A
3000	190	270	380	520	1000
	- N/A	- N/A	- N/A	- N/A	- N/A
3200	240	330	460		
	- N/A	- N/A	- N/A		
3400	290	400	550		
	- N/A	10 N/A	20 N/A		
3600	350	740			
	20 N/A	30 N/A			
3800	410				
	50 N/A				
4000					

End Spans 120mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1600	210	210	210	210	210
	- -	- -	- -	- -	- -
1800	210	210	210	210	210
	- -	- -	- -	- -	- -
2000	210	210	210	210	210
	- -	- -	- -	- -	- -
2200	210	210	210	210	230
	- -	- -	- -	- -	- -
2400	210	210	210	210	300
	- -	- -	- -	- -	- -
2600	210	210	210	250	380
	- -	- -	- -	- -	- -
2800	210	210	230	320	470
	- -	- -	- -	- -	- 20
3000	210	210	290	390	570
	- -	- 10	- -	- 20	- 50
3200	210	250	350	470	680
	- 20	- 30	- 30	- 50	10 90
3400	230	310	410	550	920
	- 50	- 40	- 50	- 80	30 120
3600	270	360	490	640	
	- 80	- 70	- 80	20 110	
3800	320	420	560		
	- 100	10 90	20 110		
4000	370	490			
	10 130	20 120			
4200	430				
	30 160				
4400	1200				
	- 160				
4600					

End Spans 140mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
1800	210	210	210	210	210
	- -	- -	- -	- -	- -
2000	210	210	210	210	210
	- -	- -	- -	- -	- -
2200	210	210	210	210	210
	- -	- -	- -	- -	- -
2400	210	210	210	210	210
	- -	- -	- -	- -	- -
2600	210	210	210	210	260
	- -	- -	- -	- -	- -
2800	210	210	210	210	340
	- -	- -	- -	- -	- -
3000	210	210	210	270	410
	- -	- -	- -	- -	- 20
3200	210	210	240	340	500
	- -	- -	- -	- 10	- 40
3400	210	210	300	410	590
	- 10	- 40	- 20	- 40	- 70
3600	210	260	360	480	690
	- 50	- 50	- 40	- 60	20 100
3800	230	310	420	560	800
	- 80	- 70	- 70	10 90	30 130
4000	280	370	490	650	
	- 100	- 80	10 90	30 120	
4200	330	430	570	740	
	20 120	20 100	30 120	40 150	
4400	370	480	630		
	30 130	30 120	40 140		
4600	420	550			
	40 150	40 150			
4800	480				
	60 180				
5000	1230				
	60 180				
5200					

End Spans 160mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 $G_{sdl}=1$	Q=2.5 $G_{sdl}=1$	Q=3.5 $G_{sdl}=1$	Q=5.0 $G_{sdl}=1$	Q=7.5 $G_{sdl}=1$
2000	200	200	200	200	200
	- -	- -	- -	- -	- -
2200	200	200	200	200	200
	- -	- -	- -	- -	- -
2400	200	200	200	200	200
	- -	- -	- -	- -	- -
2600	200	200	200	200	200
	- -	- -	- -	- -	- -
2800	200	200	200	200	220
	- -	- -	- -	- -	- -
3000	200	200	200	200	290
	- -	- -	- -	- -	- -
3200	200	200	200	230	360
	- -	- -	- -	- -	- 20
3400	200	200	200	290	440
	- -	- 10	- 30	- 10	- 40
3600	200	200	230	350	530
	- 20	- 40	- 50	- 40	- 60
3800	200	220	280	420	620
	- 60	- 70	- 60	- 60	10 90
4000	200	270	340	500	720
	10 100	- 80	- 70	10 80	30 120
4200	230	310	400	570	810
	20 110	10 100	10 80	20 100	40 140
4400	270	360	460	650	1070
	30 130	20 110	20 100	40 130	60 170
4600	320	420	530	740	
	40 140	30 130	40 130	50 160	
4800	370 480	600 1460			
	60 160	40 140	50 150	70 180	
5000	420 550	670			
	70 180	60 160	70 180		
5200	480 610				
	90 200	70 190			
5400	540				
	100 220				
5600					

End Spans 180mm slab depth

Floor loading: Q imposed 'live' (kPa) G_{sdl} permanent superimposed 'dead' (kPa)

Span (mm)	Q=1.5 G_{sdl} =1	Q=2.5 G_{sdl} =1	Q=3.5 G_{sdl} =1	Q=5.0 G_{sdl} =1	Q=7.5 G_{sdl} =1
2000	250	250	250	250	250
	- -	- -	- -	- -	- -
2200	250	250	250	250	250
	- -	- -	- -	- -	- -
2400	250	250	250	250	250
	- -	- -	- -	- -	- -
2600	250	250	250	250	250
	- -	- -	- -	- -	- -
2800	250	250	250	250	250
	- -	- -	- -	- -	- -
3000	250	250	250	250	250
	- -	- -	- -	- -	- -
3200	250	250	250	250	300
	- -	- -	- -	- -	- -
3400	250	250	250	250	370
	- -	- -	- -	- -	- 20
3600	250	250	250	300	440
	- -	- -	- 10	- 20	- 40
3800	250	250	250	360	520
	- 10	- 20	- 40	- 40	- 60
4000	250	250	290	420	610
	- 40	- 60	- 60	- 60	10 90
4200	250	270	340	480	690
	- 60	- 80	- 70	10 80	30 110
4400	250	310	400	560	790
	20 100	10 90	10 80	20 100	40 130
4600	280	370	460	630	890
	30 120	20 100	20 100	40 120	60 160
4800	330	420	520	720	1000
	40 130	30 120	40 120	50 150	80 190
5000	370	480	590	800	
	60 150	40 130	50 150	70 170	
5200	430	540	660	890	
	70 170	60 150	70 170	90 200	
5400	480	600	730		
	80 190	70 180	80 200		
5600	540	670			
	100 210	90 200			
5800	600	1840			
	110 230	110 230			
6000	1230				
	110 230				
6000					

7. Construction and detailing

The construction of BONDEK® composite slabs follows simple, familiar and widely-accepted building practice. Workers can readily acquire the skills necessary to install BONDEK® formwork and finish the composite slab. Construction workers will normally be supplied with fully detailed drawings showing the direction of the ribs, other reinforcement and all supporting details.

7.1 SAFETY

BONDEK® is available in long lengths, so large areas can be quickly and easily covered to form a safe working platform during construction. One level of formwork gives immediate protection from the weather, and safety to people working on the floor below. The minimal propping requirements provide a relatively open area to the floor below.

The bold embossments along the top of the ribs of BONDEK® enhance safety by reducing the likelihood of workers slipping.

It is commonsense to work safely, protecting yourself and workmates from accidents on the site. Safety includes the practices you use; as well as personal protection of eyes and skin from sunburn, and hearing from noise. For personal safety, and to protect the surface finish of BONDEK®, wear clean dry gloves. Don't slide sheets over rough surfaces or over each other. Always carry tools, don't drag them.

Occupational health and safety laws enforce safe working conditions in most locations. Laws in every state require you to have fall protection which includes safety mesh, personal harnesses and perimeter guardrails where they are appropriate. We recommend that you adhere strictly to all laws that apply to your site.

BONDEK® is capable of withstanding temporary construction loads including the mass of workmen, equipment and materials all in accordance with AS 3610-1995. However, it is good construction practice to ensure protection from concentrated loads, such as barrows, by use of some means such as planks and/or boards.

7.2 CARE AND STORAGE BEFORE INSTALLATION

BONDEK® is delivered in strapped bundles. If not required for immediate use, stack sheets or bundles neatly and clear of the ground, on a slight slope to allow drainage of water. If left in the open, protect with waterproof covers.

7.3 INSTALLATION OF BONDEK® SHEETING ON-SITE

7.3.1 PROPPING

Depending on the span of a BONDEK® slab, temporary propping may be needed between the slab supports to prevent excessive deflections or collapse of the formwork. A typical diagram for the installation of BONDEK® is depicted in Figure 7.1.

BONDEK® formwork is normally placed directly on prepared propping. Props shall stay in place during the laying of BONDEK® formwork, the placement of the concrete, and until the concrete has reached the strength of 15 MPa.

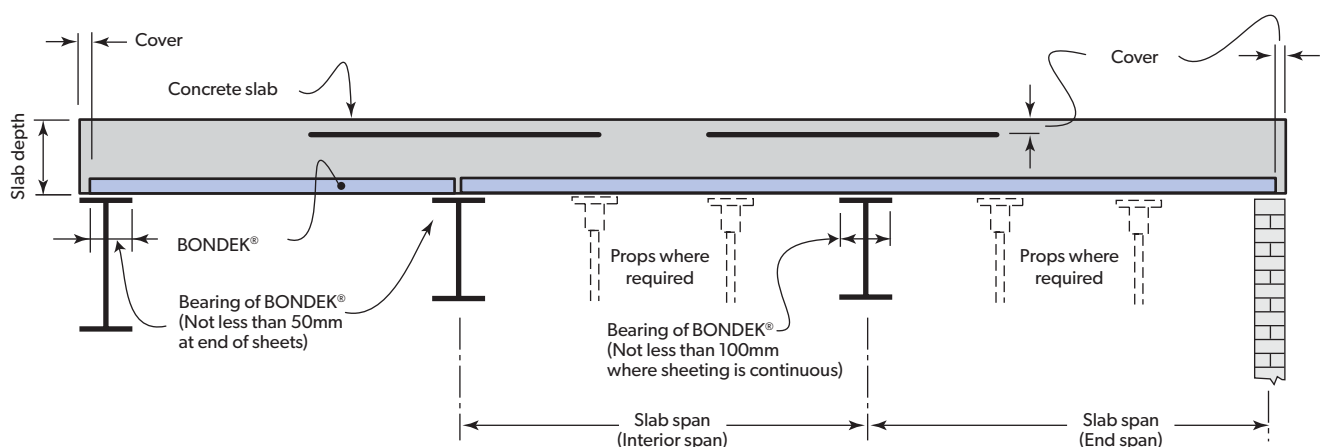
Propping generally consists of substantial timber or steel bearers supported by vertical props. The bearers shall be continuous across the full width of BONDEK® formwork.

Propping shall be adequate to support construction loads and the mass of wet concrete. The number of props you need for given spans is shown in our tables.

If sheets don't interlock neatly (perhaps due to some damage or distortion from site handling or construction practices) use screws to pull the laps together tightly (see Section 7.3.9, Fastening side-lap joints).

Figure 7.1

BONDEK® Installation guidelines.



7.3.2 LAYING

BONDEK® shall be laid with the sheeting ribs aligned in the direction of the designed spans. Other details include the following:

- The slab supports shall be prepared for bearing and slip joints as required.
- Lay BONDEK® sheets continuously over each slab span without any intermediate splicing or jointing.
- Lay BONDEK® sheets end to end. Centralise the joint at the slab supports. Where jointing material is required the sheets may be butted against the jointing material.
- Support BONDEK® sheets across their full width at the slab support lines and at the propping support lines.
- For the supports to carry the wet concrete and construction loads, the minimum bearing is 50mm for ends of BONDEK® sheets, and 100mm for intermediate supports over which the sheeting is continuous. It may be reduced to 25mm for concrete band beams as shown in Figure 7.5.
- In exposed applications, treat the end and edges of the BONDEK® sheets with a suitable edge treatment to prevent entry of moisture.

7.3.3 INTERLOCKING OF SHEETS

Overlapping ribs of BONDEK® sheeting are interlocked. Either of two methods can be used in most situations, though variations may also work.

In the first method, lay adjacent sheets loosely in place. Place the female lap rib overlapping the male lap rib of the previous sheet and apply foot pressure, or a light kick, to the female lap rib (Figure 7.2).

In the second method, offer a new sheet at an angle to one previously laid, and then simply lower it down, through an arc (see Figure 7.2).

7.3.4 SECURING THE SHEETING PLATFORM

BONDEK® shall be securely fixed to supporting structures using:

- weights;
- screws or nails into the propping bearers; or
- Spot welding

Take care if you use penetrating fasteners (such as screws and nails) because they can make removal of the props difficult, and perhaps result in damage to the BONDEK®.

7.3.5 INSTALLING BONDEK® ON STEEL FRAMES

BONDEK® may be installed directly on erected structural steelwork.

GENERAL FASTENING OF BONDEK®

To provide uplift resistance or lateral restraint, the sheeting may be fixed to the structural steel using spot welds, or fasteners such as drive nails or self-drilling screws.

At a movement joint, the sheeting is not continuous over the support. If one sheet is fastened at the joint, the other is not.

Place the fixings (fasteners and spot welds) in the flat areas of the pans adjacent to the ribs or between the flutes. The frequency of fixings depends on wind or seismic conditions and good building practice.

One fixing system is as follows.

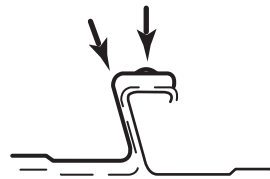
- At the end of sheets: use a fixing at every rib (Figure 7.3).
- At each intermediate slab support over which the sheeting is continuous: use a fixing at the ribs on both edges (Figure 7.3).
- Fix BONDEK® with drive nails, self-drilling screws or spot welds.
- Drive nails should be powder-activated, steel nails 4mm nominal diameter, suitable for structural steel of 4mm thickness or greater.
- For structural steel up to 12mm thick, use 12-24x38mm self-drilling self-tapping hexagon head screws.
- For structural steel over 12mm thick, pre-drill and use 12-24x16mm hexagon head screws.
- Spot welds should be 12mm minimum diameter. Use 3.25mm diameter cellulose, iron powder AC/DC high penetration electrodes. Surfaces to be welded shall be free of loose material and foreign matter. Where the BONDEK® soffit or the structural steelwork has a pre-painted surface, securing methods other than welding may be more appropriate. Take suitable safety precautions against fumes during welding zinc coated products.

Figure 7.2

Two methods of interlocking two adjacent BONDEK® sheets.

Method 1

Position BONDEK® sheet parallel with previously-laid sheet. Interlock sheets by applying pressure to either position.



Method 2

Position BONDEK® sheet at an angle. Interlock sheets by lowering sheet through an arc.



Figure 7.3

Positions for fixing BONDEK® sheet to steel framing.



Fixing at end of sheets.



Fixing at intermediate slab supports over which the sheeting is continuous.

FASTENING COMPOSITE BEAMS

In projects of composite beam construction the BONDEK® sheeting shall be fastened in accordance with AS 2327, Clause 9.2 (Composite beams with slabs incorporating profiled steel sheets). This provision requires a fixing in each pan at each composite beam.

Stud welding through the sheet has been considered a suitable securing method for the sheeting in a composite beam; however some preliminary fixing by one of the methods mentioned above is necessary to secure the sheeting prior to the stud welding. Stud welding should comply with the requirements of AS 1554, Part 2 and AS 2327, Part 1. Some relevant welding requirements are:

- Zinc coating on sheeting not to exceed Z450;
- Mating surfaces of steel beam and sheeting to be cleaned of scale, rust, moisture, paint, overspray, primer, sand, mud or other contamination that would prevent direct contact between the parent material and the BONDEK®;
- Welding shall be done in dry conditions by a certified welder;
- For pre-painted BONDEK® sheets, special welding procedures may be necessary; and
- For sheets transverse to beams, stud welding shall be between pan flutes to ensure there is no gap between mating surfaces.

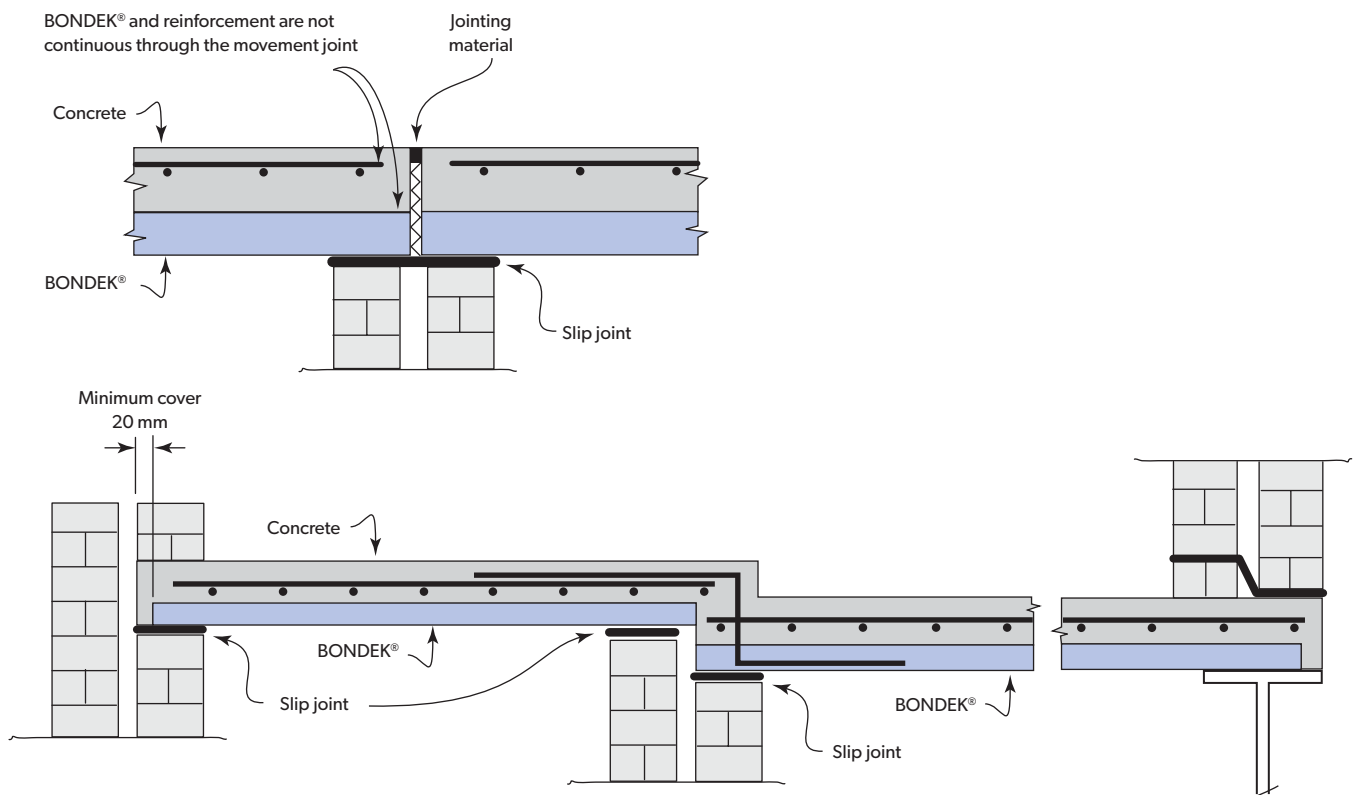
Note: Welding may void warranty as well as damaging steel support.

7.3.6 INSTALLING BONDEK® ON BRICK SUPPORTS

Brick walls are usually considered to be brittle and liable to crack from imposed horizontal loads. Thermal expansion and contraction, long-term shrinkage, creep effects and flexural deflection of concrete slabs may be sufficient to cause such cracking.

Figure 7.4

Typical movement and slip joints.



To prevent the cracking, BONDEK® slabs are not usually installed directly on brick supports, although this is not always the case in earthquake construction.

SLIP JOINTS

Generally, a slip joint is provided between BONDEK® and masonry supports (Figure 7.4).

- No fasteners are used between BONDEK® and its support at a slip joint.
- Slip joint material may be placed directly in contact with the cleaned surface of steelwork.
- The top course of masonry should be level, or finished with a levelled bed of mortar to provide an even bearing surface. Lay the top courses of bricks with the frogs facing down.
- The width of a slip joint should not extend beyond the face of the slab support.
- The slip joint material shall have adequate compressive strength to avoid it being compressed into irregularities of the mating surfaces and thus becoming a rigid joint.

Slip joint material shall allow movement to occur, usually by allowing flow under pressure or temperature, however it shall not run or solidify. Generically, the materials are a non-rotting, synthetic carrier impregnated with a neutral synthetic or petroleum-based material. Typical slip joint material is Alcor (a bitumen coated aluminium membrane).

Note: Earthquake zones will require special detailing.

7.3.7 INSTALLING BONDEK® ON CONCRETE FRAMES

When used in concrete frame construction, the BONDEK® sheeting is discontinuous through the supports (Figure 7.5).

7.3.8 PROVISION OF CONSTRUCTION AND MOVEMENT JOINTS

Joints used between BONDEK® slabs generally follow accepted construction practices. Construction joints are included between slabs for the convenience of construction. Movement joints allow relative movement between adjoining slabs. The joints may be transverse to, or parallel with, the span of the BONDEK® slab. Movement joints need a slip joint under the BONDEK® sheeting. (Figure 7.4).

Joints typically use a non-rotting, synthetic carrier impregnated with a neutral synthetic or petroleum based material like Malthoid (a bitumen impregnated fibre-reinforced membrane). Sometimes a sealant is used in the top of the joint for water tightness.

The BONDEK® sheeting and any slab reinforcement are not continuous through a joint.

Design engineers generally detail the location and spacing of joints because joints effect the design of a slab.

7.3.9 FASTENING SIDE-LAP JOINTS

If BONDEK® sheeting has been distorted in transport, storage or erection, side-lap joints may need fastening to maintain a stable platform during construction, to minimise concrete seepage during pouring, and to gain a good visual quality for exposed soffits (Figure 7.6).

7.3.10 CUTTING AND FITTING EDGEFORM

Edgeform is a simple C-shaped section that simplifies the installation of most BONDEK® slabs. It is easily fastened to the BONDEK® sheeting, neatly retaining the concrete and providing a smooth top edge for quick and accurate screeding. We make it to suit any slab thickness.

Edgeform is easily spliced and bent to form internal and external corners of any angle and shall be fitted and fully fastened as the sheets are installed. There are various methods of forming corners and splices. Some of these methods are shown in Figures 7.7 and 7.8.

Fasten Edgeform to the underside of unsupported BONDEK® panels every 300mm. The top flange of Edgeform shall be tied to the ribs every 600mm (or less if aesthetics are required) with straps formed on-site using builder's strapping 25mm x 1.0mm (Figures 7.7 and 7.8). Use 10-16x16mm self-drilling screws.

Make sure that the zinc coating on Edgeform matches the corrosion protection requirements of your job.

Figure 7.5

BONDEK® is discontinuous in concrete frame construction.

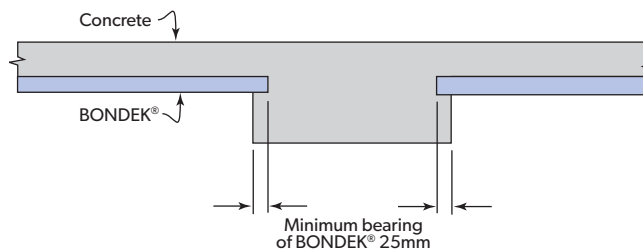


Figure 7.6

Fixing at a side-lap.

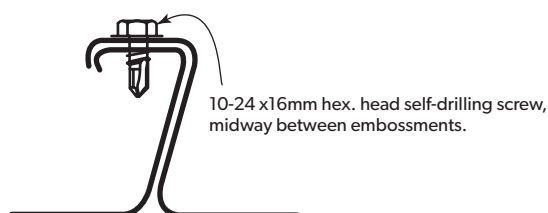
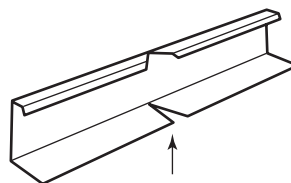


Figure 7.7

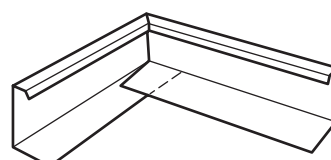
Fabrication of formwork is easy with Edgeform.

External corner

1. Notch top flange for the required angle

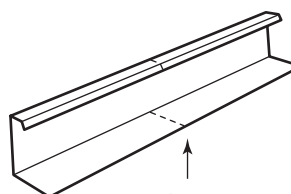


2. Cut 'V' in bottom flange



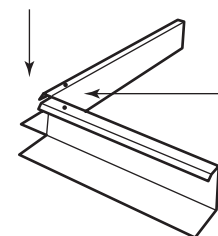
3. Bend corner of Edgeform to the required angle, overlapping bottom flanges.

Internal corner



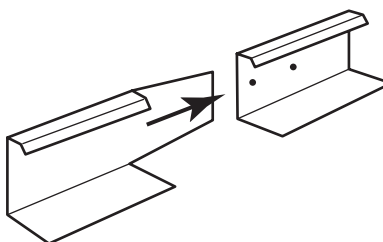
1. Cut top and bottom flanges square.

2. Bend Edgeform to required angle.



3. Fasten top flange, each side of corner, to BONDEK® rib, 100mm maximum from corner.

Splicing two pieces



1. Cut-back top and bottom flanges of one Edgeform section approximately 600mm.
2. Cut slight taper on web.
3. Slide inside adjoining Edgeform, and fasten webs with at least 2 screws.

7.3.11 CUTTING OF SHEETING

It is easy to cut BONDEK® sheets to fit. Use a power saw fitted with an abrasive disc or metal cutting blade. Initially lay the sheet with its ribs down, cut through the pans and part-through the ribs, then turn over and finish by cutting the tops of the ribs.

7.3.12 ITEMS EMBEDDED IN SLABS

Generally use items in a manner which complies with AS 3600:2009, Clause 17.4, and Clause 17.5. Included are pipes and conduits, sleeves, inserts, holding-down bolts, chairs and other supports, plastic strips for plasterboard attachment, contraction joint material and many more.

Table 7.1

Location of items within the slab (Figure 7.9).

Items	Location
Pipes parallel with the ribs and other items	<ul style="list-style-type: none">Between the ribs; andbelow the top-face reinforcement; andabove the pans and flutes of the BONDEK®
Pipes across the ribs	In the space between the top-face and bottom-face reinforcements (if there is no bottom-face reinforcement, above the top of the ribs)

Minimise the quantity and size of holes through BONDEK® sheeting, by hanging services from the underside of BONDEK® using accessories such as Bon-nut and BONWEDGE®.

Figure 7.8

Typical fastening of Edgeform to BONDEK®.

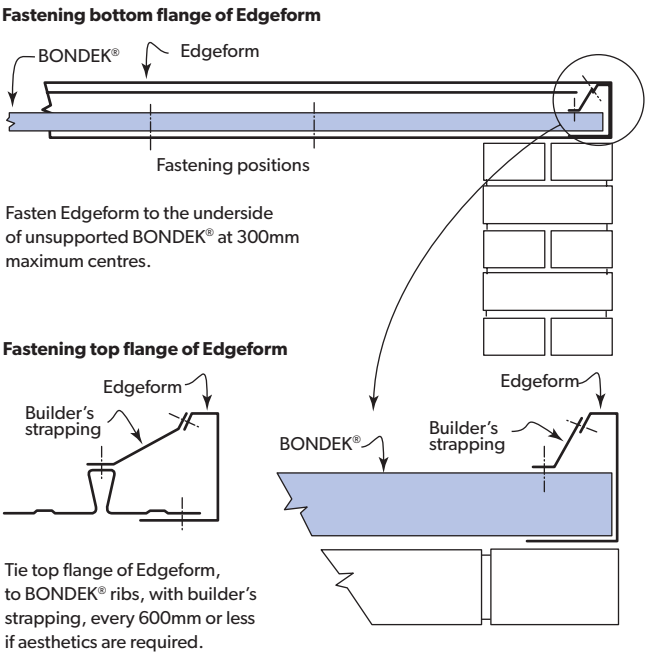
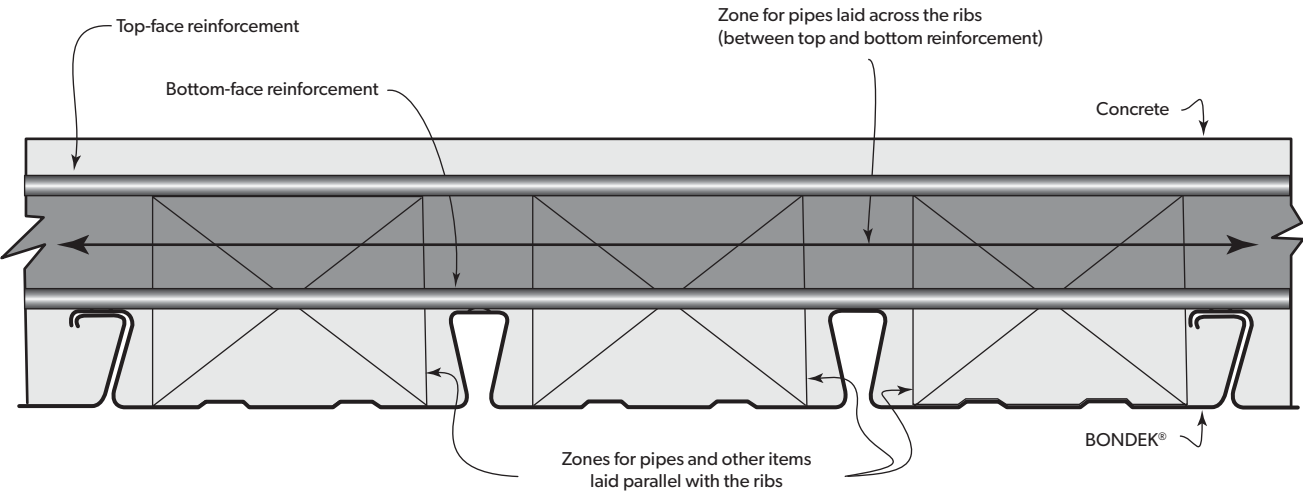


Figure 7.9

Zones for the location of holes through BONDEK®.



7.3.13 HOLES IN SHEETING

BONDEK® acts as longitudinal tensile reinforcement similarly to conventional bar or fabric reinforcement does in concrete slabs. Consequently, holes in BONDEK® sheets, to accommodate pipes and ducts, reduce the effective area of the steel sheeting and can adversely effect the performance of a slab.

Some guidelines for holes are: (Figure 7.11)

- Place holes in the central pan of any sheet, with a minimum edge distance of 15mm from the rib gap.
- Holes should be round, with a maximum diameter of 150mm.
- For slabs designed as a continuous slab: space holes from an interior support of the slab no less than one tenth of a clear span.

Note: In the event of BONDEK® ribs being cut for larger penetrations, sufficient reinforcing steel and detailing is required to replace lost BONDEK® ribs. Attention to propping at these locations is essential.

7.3.14 SEALING

Seepage of water or fine concrete slurry can be minimised by following common construction practices. Generally gaps are sealed with waterproof tape, or BONFILL® (Figure 7.10) or by sandwiching contraction joint material between the abutting ends of BONDEK® sheet. If there is a sizeable gap you may have to support the waterproof tape.

7.3.15 INSPECTION

BONDEK® sheeting acts as longitudinal tensile reinforcement.

The condition of sheeting should be inspected before concrete is poured.

We recommend regular qualified inspection during the installation, to be sure that the sheeting is installed in accordance with this publication and good building practice.

Figure 7.10

Typical sealing of BONDEK®. Use waterproof tape to seal joints in BONDEK® sheets.

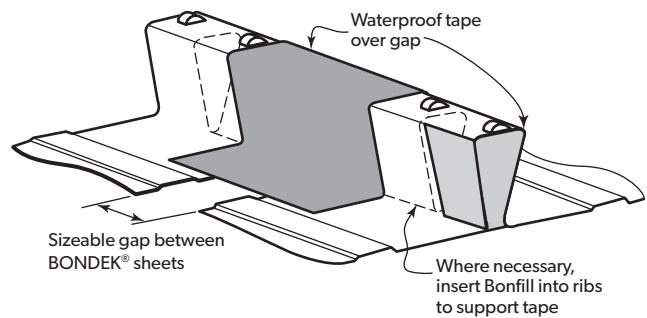
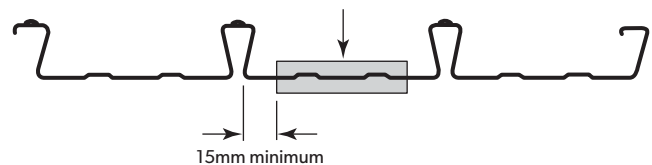


Figure 7.11

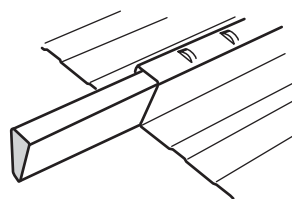
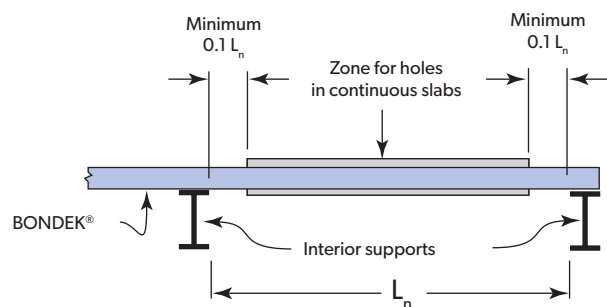
Penetration through BONDEK® sheets.

Location of holes in sheet

Zone for holes through BONDEK® sheet in central pan
Max. diameter 150mm



Location of holes relative to supports in continuous slabs



BONFILL®

Polystyrene foam stops concrete and air entering ends of ribs.
Stock length: 1200mm.
Required: 300mm per sheet of BONDEK®.



END PLUG

Polyethylene end plug stops concrete and air from entering end of BONDEK® ribs.

7.4 POSITIONING AND SUPPORT OF REINFORCEMENT

Reinforcement in slabs carries and distributes the design loads and to control cracking. Reinforcement is generally described as transverse and longitudinal in relation to span, but other reinforcement required for trimming may be positioned in other orientations. Figure 7.12 shows a typical cross-section of a BONDEK® composite slab and associated terms.

Reinforcement shall be properly positioned, lapped where necessary to ensure continuity, and tied to prevent displacement during construction. Fix reinforcement in accordance with AS 3600:2009, Clause 17.2.5 (Fixing).

To ensure the specified minimum concrete cover, the uppermost layer of reinforcement shall be positioned and tied to prevent displacement during construction (Section 4.4 of this Manual).

Splicing of conventional reinforcement shall be in accordance with AS 3600:2009, Clause 13.2 (Splicing of reinforcement).

Where fabric is used in thin slabs, or where fabric is used to act as both longitudinal and transverse reinforcement, pay particular attention the required minimum concrete cover and the required design reinforcement depth at the splices-splice bars are a prudent addition.

Always place chairs and spacers on pan areas. Depending upon the type of chair and its loading, it may be necessary to use plates under chairs to protect the BONDEK®, particularly where the soffit will be exposed. Transverse reinforcement may be used for spacing or supporting longitudinal reinforcement.

7.4.1 TRANSVERSE REINFORCEMENT

Transverse reinforcement is placed at right-angles to the ribs of BONDEK®. Deformed bar or fabric reinforcement may be used. In most applications the transverse reinforcement is for the control of cracks caused by shrinkage and temperature effects, and for locating longitudinal reinforcement.

For ease of construction, reinforcement for control of cracking due to shrinkage and temperature effects is usually fabric reinforcement. It may be located anywhere within the depth of the slab if total thickness does not exceed 250mm. Two layers would be necessary for thicker slabs. Design tables presented in this manual can be used if mesh is located as shown in Figure 7.12

7.4.2 LONGITUDINAL REINFORCEMENT

Longitudinal reinforcement is positioned to carry design loads in the same direction as the ribs of BONDEK®. Deformed bar or fabric reinforcement may be used.

Top-face longitudinal reinforcement is usually located over interior supports of the slab and extends into approximately a third of the adjoining spans.

Bottom-face longitudinal reinforcement is located between supports of the slab but, depending upon the detailing over the interior supports, it may be continuous, lapped, or discontinuous. Bottom-face longitudinal reinforcement may be placed on top of or below transverse reinforcement.

Location of top and bottom-face longitudinal reinforcement in elevated temperatures requires special design. (Refer Section 5 of this Manual)

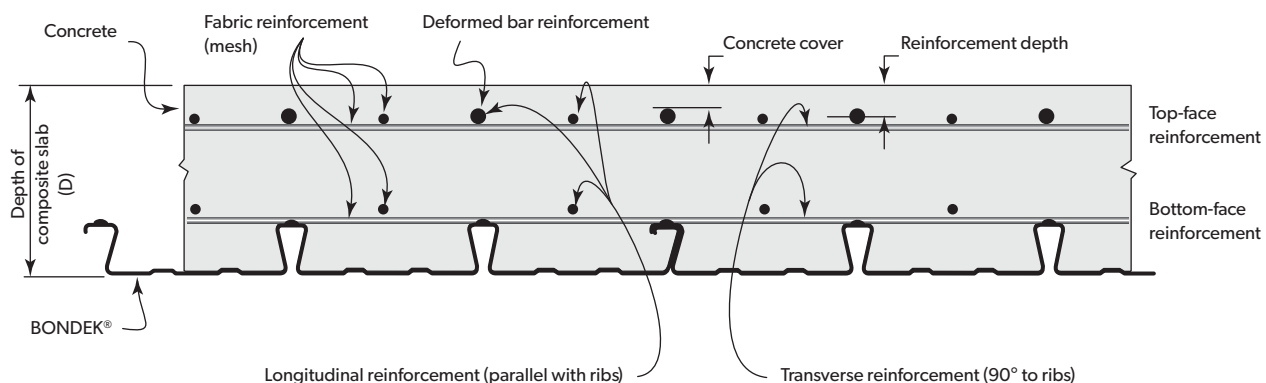
7.4.3 TRIMMERS

Trimmers are used to distribute the design loads to the structural portion of the slab and/or to control cracking of the concrete at penetrations, fittings and re-entrant corners. Deformed bar or fabric reinforcement may be used.

Trimmers are sometimes laid at angles other than along or across the span, and generally located between the top and bottom layers of transverse and longitudinal reinforcement. Trimmers are generally fixed with ties to the top and bottom layers of reinforcement.

Figure 7.12

Typical cross section of a slab showing common terms.



7.5 CONCRETE

7.5.1 SPECIFICATION

The concrete is to have the compressive strength as specified in the project documentation and the materials for the concrete and the concrete manufacture should conform to AS 3600:2007.

7.5.2 CONCRETE ADDITIVES

Admixtures or concrete materials containing calcium chloride or other chloride salts shall not be used. Chemical admixtures including plasticisers may be used if they comply with AS 3600:2009, Clause 17.

7.5.3 PREPARATION OF SHEETING

Before concrete is placed, remove any accumulated debris, grease or any other substance to ensure a clean bond with the BONDEK® sheeting. Remove ponded rainwater.

7.5.4 CONSTRUCTION JOINTS

It is accepted building practice to provide construction joints where a concrete pour is to be stopped. Such discontinuity may occur as a result of a planned or unplanned termination of a pour. A pour may be terminated at the end of a day's work, because of bad weather or equipment failure. Where unplanned construction joints are made, the design engineer shall approve the position.

In certain applications, the addition of water stops may be required, such as in roof and balcony slabs where protection from corrosion of reinforcement and sheeting is necessary.

Construction joints transverse to the span of the BONDEK® sheeting are normally located at the mid-third of a slab span and ideally over a line of propping. Locate longitudinal construction joints in the pan (Figure 7.13).

It may be necessary to locate joints at permanent supports where sheeting terminates. This is necessary to control formwork deflections since formwork span tables are worked out for uniformly distributed loads (UDL) applied on all formwork spans.

Form construction joints with a vertical face - the easiest technique is to sandwich a continuous reinforcement between two boards.

Prior to recommencement of concreting, the construction joint shall be prepared to receive the new concrete, and the preparation method will depend upon the age and condition of the old concrete. Generally, thorough cleaning is required to remove loose material, to roughen the surface and to expose the coarse aggregate.

7.5.5 PLACEMENT OF CONCRETE

The requirements for the handling and placing of the concrete are covered in AS 3600:2009, Clause 17.1.3.

The concrete is placed between construction joints in a continuous operation so that new concrete is placed against plastic concrete to produce a monolithic mass. If the pouring has to be discontinued for any more than approximately one hour, depending on the temperature, a construction joint may be required.

Start pouring close to one end and spread concrete uniformly, preferably over two or more spans. It is good practice to avoid excessive heaping of concrete and heavy load concentrations. When concrete is transported by wheel barrows, the use of planks or boards is recommended.

During pouring, the concrete should be thoroughly compacted, worked around ribs and reinforcement, and into corners of the edge forms by using a vibrating compactor. Ensure that the reinforcement remains correctly positioned so that the specified minimum concrete cover is achieved.

Unformed concrete surfaces are screeded and finished to achieve the specified surface texture, cover to reinforcement, depths, falls or other surface detailing.

Surfaces which will be exposed, such as Edgeform and exposed soffits, should be cleaned of concrete spills while still wet, to reduce subsequent work.

7.5.6 CURING

After placement, the concrete is cured by conventional methods, for example, by keeping the slab moist for at least seven days, by covering the surface with sand, building paper or polythene sheeting immediately after it has been moistened with a fine spray of water. Follow AS 3600:2009, Clause 17.1.5 (Curing and protection of concrete) and good building practice. Be particularly careful when curing in very hot or very cold weather.

Until the concrete has cured, it is good practice to avoid concentrated loads such as barrows and passageways with heavy traffic.

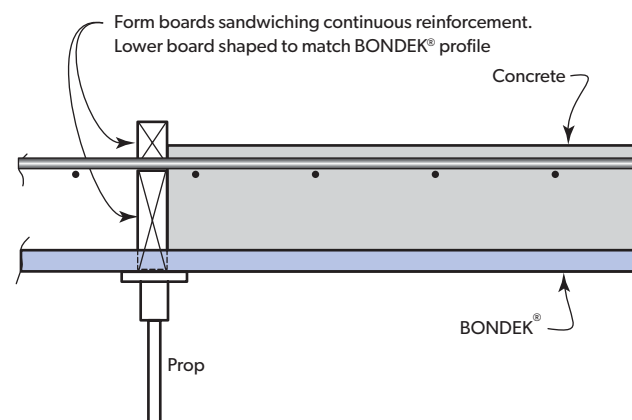
7.5.7 PROP REMOVAL

Various factors affect the earliest time when the props may be removed and a slab is initially loaded. Methods of calculating times and other guides are given in AS 3610:1995, Clause 5.4.3 (Stage III of construction - Formwork stripping and after placement of concrete).

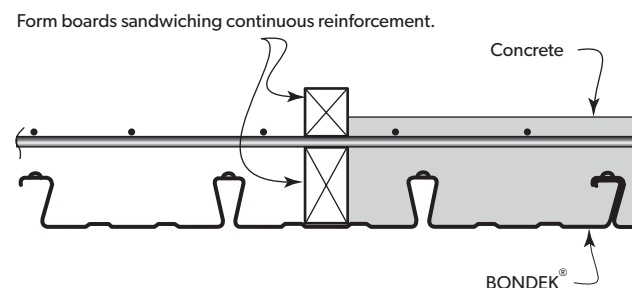
Figure 7.13

Typical construction joint.

Transverse construction joint



Longitudinal construction joint



7.6 FINISHING

7.6.1 SOFFIT AND EDGEFORM FINISHES

For many applications, BONDEK® gives an attractive appearance to the underside (or soffit) of a composite slab, and will provide a satisfactory ceiling - for example, in car parks, under-house storage and garages, industrial floors and the like. Similarly, Edgeform will give a suitable edging. Additional finishes take minimal extra effort.

Where the BONDEK® soffit is to be the ceiling, take care during construction to minimise propping marks (refer to Installation - Propping), and to provide a uniform surface at the side-laps (refer to Installation - Fastening side-lap joints).

Exposed surfaces of BONDEK® soffit and Edgeform may need cleaning and/or preparation for any following finishes. The cleaning preparations are shown in Table 7.2.

7.6.2 PAINTING

Various painting systems are available for use with zinc coatings to provide a decorative finish and/or to provide an appropriate corrosion protection system.

There are recommendations suitable for painting soffits and edges in Painting zinc-coated or ZINCALUME® steel sheet (BlueScope Lysaght technical information booklet). Field (on-site) painting systems from that booklet are summarised in Table 7.3.

The performance of a paint system is influenced by the quality of preparation and application - closely follow the paint manufacturer's instructions.

For painted soffits, it may be preferable to cover the gaps of the ribs prior to painting. BONSTRIP® snaps into the gaps of the ribs of the BONDEK® sheeting and produces an attractive appearance (Figure 7.14).

The gap at the side-lap joint can be filled with a continuous bead of silicon sealant prior to painting.

Note: Overpainting will void any warranties issued by BlueScope Steel. Paint manufacturers' approved applicators provide the performance warranty for overpainted products. Refer BlueScope Steel Technical Bulletin TB-2 for further information.

7.6.3 PLASTERING

Finishes such as vermiculite plaster can be applied directly to the underside of BONDEK® with the open rib providing a positive key. With some products it may be necessary to treat the galvanised steel surface with an appropriate bonding agent prior to application.

7.6.4 ADDITION OF FIRE PROTECTIVE COATING

Where a building is being refurbished, or there is a change of occupancy and floor use, you may need to increase the fire resistance of the BONDEK® composite slabs. This may be achieved by the addition of a suitable fire-protection material to the underside of the slabs. The open ribs of BONDEK® provide a positive key to keep the fire spray in position. Such work is beyond the scope of this manual.

Table 7.2

Preparation of soffits and Edgeform.

Pre-painted soffit or edge	<ul style="list-style-type: none"> Remove all protective plastic strips from rolled corners. Concrete seepage marks and dirt may be removed by washing with water. For stubborn stains, use a mild solution of pure soap or non-abrasive detergent in warm water. Grease or oil deposits may be removed by washing as described above. For stubborn deposits contact us for advice. Never use abrasive or solvent type cleaners (like turps, petrol or kerosene) on pre-painted steel.
Galvanised soffit or edge	<ul style="list-style-type: none"> Light corrosion marks indicated by white to grey staining due to wet bundles may be removed with a kerosene rag. If this is unsatisfactory, then wire brushing may be necessary. Take care not to unnecessarily remove any of the zinc coating. If zinc coating is removed, a suitable paint system must be used. Grease or oil deposits may be removed with a kerosene rag. For stubborn deposits, use paint thinners. Concrete seepage marks and dirt to be removed by washing as described above.

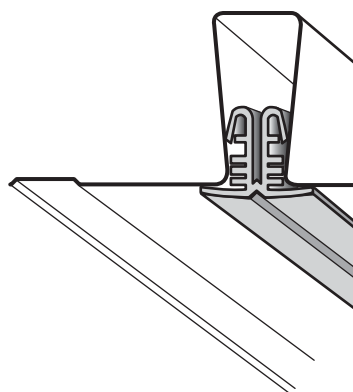
Table 7.3

Painting BONDEK® soffits and Edgeform.

Exposure classification (AS 3600)	Primer		Finish	
	Type	Application	Type	Application
A1 & A2	Water-borne acrylic (1 coat)	Brush	Water-borne acrylic (2 coats)	Brush
B1	2-pack etch primer (1 coat)	Brush or spray	Alkyd (2 coats)	Brush or spray
			Oleoresinous/ micaceous iron oxide (2 coats)	Brush or spray
	Zinc dust/zinc oxide (1 coat)	Brush or spray	Alkyd (2 coats)	Brush or spray
			Oleoresinous/ micaceous iron oxide (2 coats)	Brush or spray
B2	2-pack etch primer (1 coat)	Brush or spray	High build vinyl (2 coats)	Spray
			2-pack polyurethane (2 coats)	Brush or spray

Figure 7.14

BONSTRIP® makes an attractive cover for the gaps formed by BONDEK® ribs.



7.7 SUSPENDED CEILINGS AND SERVICES

7.7.1 PLASTERBOARD

A BONDEK® soffit may be covered with plasterboard by fixing to battens or direct fixing using BONSTRIP®.

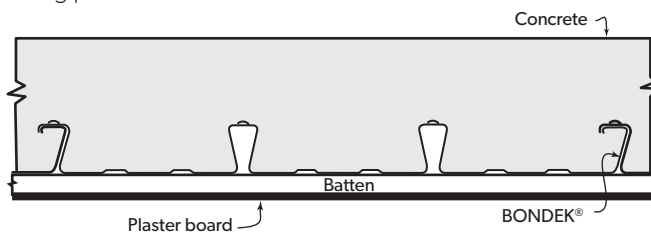
OPTION 1

Steel ceiling battens can be fixed directly to the underside of the slab using powder-actuated fasteners. The plasterboard is then fixed to ceiling battens in the usual way (Figure 7.15).

Plaster-based finishes can be trowelled smooth, or sprayed on to give a textured surface. They can also be coloured to suit interior design requirements.

Figure 7.15

Fixing plasterboard to BONDEK®.

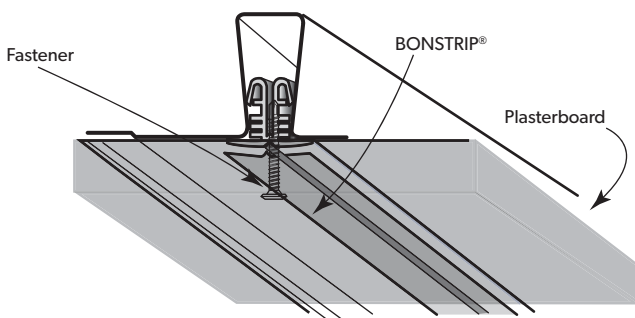


OPTION 2:

Figure 7.16

Direct fix to BONSTRIP®.

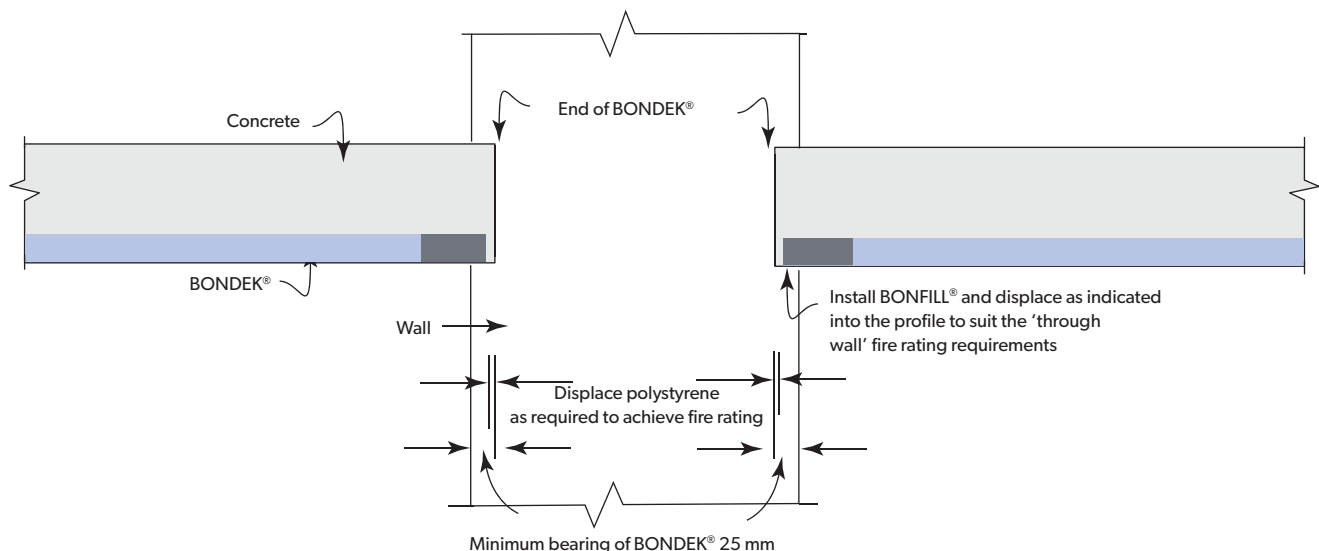
Plasterboard may also be screwed directly into BONSTRIP® using appropriate fasteners.



Note: With this detail attention to formwork, deflection limitations and service routes is critical.

Figure 7.17

BONDEK® fire detail at reinforced block walls.



7.7.2 SUSPENDED CEILING

Ceilings are easily suspended from BONDEK® slabs using M6 Bon-nut suspension nuts, or BONWEDGE® suspension brackets which comply with the load capacity requirements of AS 2785. Threaded rods or wire hangers are then used to support the ceiling. Alternatively, hangers may be attached to eyelet pins powder-driven into the underside of the slab, or to pigtail hangers inserted through pilot holes in the BONDEK® sheeting before concreting (Figure 7.21).

7.7.3 SUSPENDED SERVICES

Services such as fire sprinkler systems, piping and ducting are easily suspended from BONDEK® slabs using Bon-nut suspension nuts which comply with the load capacity requirements of AS 2118 (Figure 7.21).

7.8 FIRE STOPPING DETAILING

7.8.1 AT REINFORCED BLOCK WALLS

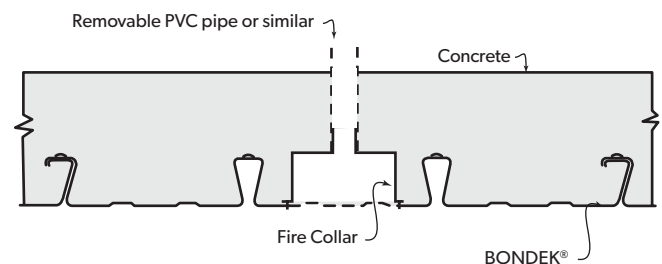
When using BONDEK® with reinforced block walls the bearing length is often reduced to 25mm absolute minimum to allow adequate bearing prior to core filling from the deck level and continuation of wall reinforcement. (An alternative is to provide holes through pans over every blockwork core.) The BONDEK® sheets still require fixing to the support structure. To maintain the fire rating level (FRL) of the (often reinforced) blockwork, the BONFILL® can be displaced relative to the end of the BONDEK® sheets as shown in Figure 7.17 to maintain the minimum through wall FRL requirement.

7.8.2 FIRE COLLARS

BONDEK® with its flat pan profile allows easy integration of proprietary fire collars that maintain the fire rating level through service penetrations as shown in Figure 7.18. They are generally up to 150mm diameter and are installed between the composite BONDEK® ribs. Fire collars are fixed pre-pour usually by the plumbing contractor with screws to the BONDEK® pan which is cut out after the pour is complete with the fire collar cast in place.

Figure 7.18

Proprietary fire collar fixed to BONDEK® pan.



7.9 BONDEK® IN POST TENSIONED CONCRETE FRAMED CONSTRUCTION

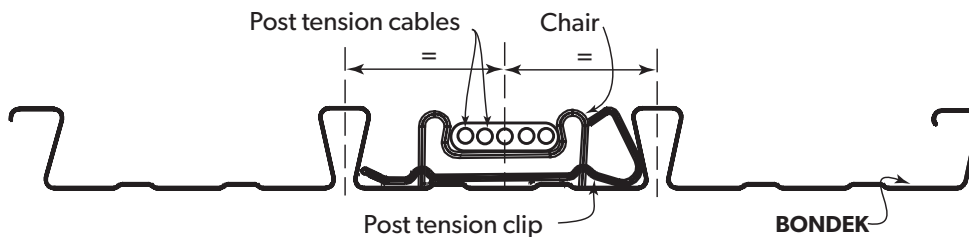
7.9.1 BONDEK® PT CLIP (POST TENSIONED)

BONDEK® is commonly used as permanent formwork in post tensioned (PT) solutions. The post tensioning clip locks into the BONDEK® pan providing a secure anchoring point for the post tensioning duct chairs to be fixed onto. These clips will not move or dislodge during a concrete pour which is crucial for the post tensioning profile shape and structural performance.

In particular central location of tendons between BONDEK® ribs is necessary to achieve desired fire rating - presence of BONDEK® will not affect fire performance of PT slabs for up to 3 hours fire rating.

Figure 7.19

PT clip and chair assist in the correct positioning of post tensioning duct/cables.



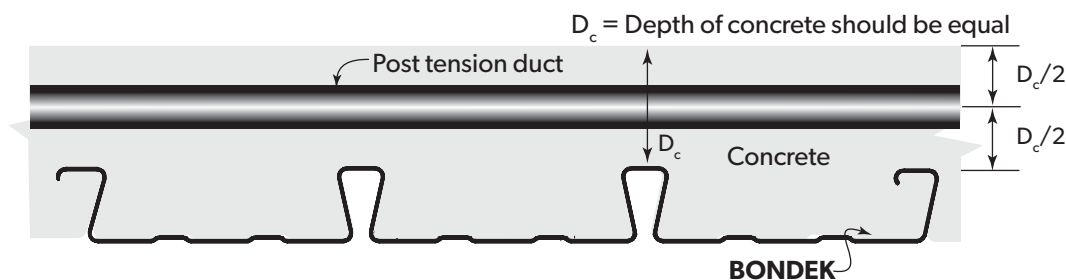
7.9.2 BONDEK® RIB REMOVAL AT PT ANCHOR POINTS OR STRESSING PANS

With post tensioned solutions dead and live anchor points can be located within slabs at a point over the BONDEK® profile. To position bursting reinforcement or to install a stressing pan within a slab a short length of BONDEK® rib is sometimes removed using a grinder or plasma cutter on site. This provides better end anchorage zone stress distribution to avoid stress concentrations between ribs. This zone where the rib is removed is sealed (usually with tape) before placing the post tensioning end termination component. (Refer to Sealing, Section 7.3.14 and Figure 7.10).

7.9.3 POSITIONING OF PT DUCT/CABLES IN TRANSVERSE DIRECTION

Figure 7.20

Positioning of PT duct/cables in transverse direction.



Notes:

1. Position transverse duct/cables equidistant between top of BONDEK® ribs and the surface of the concrete.
2. Equidistant location of duct/cables is necessary at BONDEK® open ribs and side-lap joint locations to ensure uniform compression stress across composite slab depth.

7.10 ARCHITECTURAL MATTERS

Where structural decking soffits are visible and in particular where BRITEWITE® pre-painted finishes are employed, special care must be taken when lifting, handling, storing on-site and laying this product. The underside is intended as an aesthetic feature of the installed product. For this reason, the following architectural aims need to be considered.

RIB ALIGNMENT:

Or “registration” of ribs between adjacent spans. Be careful to align the BONDEK® ribs where sheets meet over supporting beams so that when viewing the exposed product from the underside, the product presents uniform shadow lines between bays. Ensure that the sheets are laid in accordance with Section 7.3.2 end to end (or butting against jointing material) and have the ribs aligned.

FIXING:

No activities should be carried out on the topside of the installed BONDEK® that might have adverse affects on the bottom side, such as puddle welding or penetrating the deck with fasteners in locations where they will be visible from the underside. Securing the decking plan to the supporting structure as recommended in Section 7.3 will prevent movement of sheets and reduce slurry leakage under the sheets during pouring and vibration of the concrete.

SLURRY LEAKAGES:

During the concrete pour ensure there is no concrete leakage which might cause unsightly stains on the underside paint finish. Refer to Section 7.3.14 regarding sealing at ends and laps and Section 7.3.9 regarding side-lap fixing. Foam tape should be utilised under the deck edges over the supporting structure (particularly in concrete frames) to minimise leakage under the sheets.

HANDLING:

Section 7.2 covers care and storage before installation. With architectural finishes such as BRITEWITE®, which has plastic CORSTRIP® or SPOT-STIK® (or equivalent) applied to the decking soffit, special care is still required to minimise scratching and marking prior to placement. (i.e. during transport, site storage and handling of bundles and placement of individual sheets).

VISUAL QUALITY:

a) Prop marking - Care should be taken to minimise prop marking through maintaining the quality of temporary propping support surfaces and adopting deflection ratio limitations in accordance with Section 3.2. Care in controlling construction live loads such as workman, mounding of concrete and stacked materials will also improve the visual quality.

b) Side-lap - Refer section 7.3.9 where visual quality of exposed soffits can be enhanced with side-lap fixing.

FINISHING:

Section 7.3.14 covers gap sealing of the decking profile and jointing details. Utilising waterproof tape, BONFILL®, and end plugs will control seepage of water or fine concrete slurry.

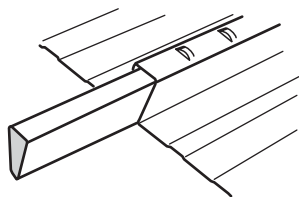
PROTECTIVE FILMS:

BRITEWITE® is DECKFORM® steel pre-painted with a SURFMIST® colour finish and has a CORSTRIP® protective film applied prior to roll forming. Store out of direct sunlight for ease of removal. It is generally installed before CORSTRIP® removal which tends to come off in narrow strips and typically has to be cut away from the laps and supports with a blade.

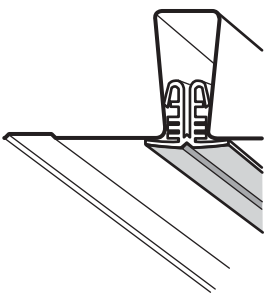
The removal of protective film can be made easier and soffit finish improved through the use of SPOT-STIK® coating (or equivalent) applied only to the flat pan of the profile during roll forming. The BRITEWITE® is supplied with a backing coat to prevent scuffing of the SURFMIST® colour soffit finish prior to roll forming. SPOT-STIK® coating (or equivalent) is subject to enquiry and currently only available in NSW on permanent formwork applications.

7.11 ACCESSORIES

Figure 7.21
BONDEK® accessories.



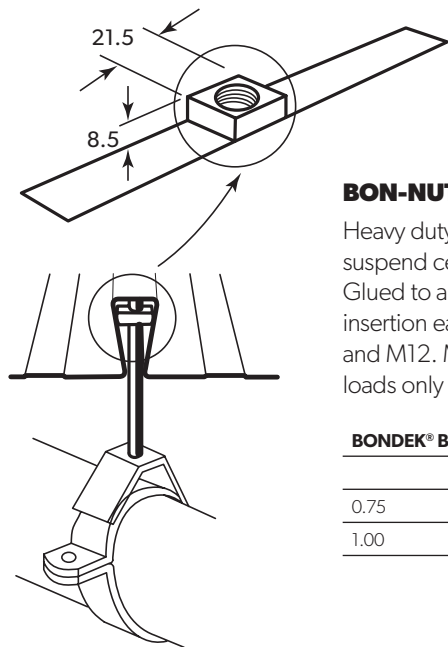
BONFILL®
Polystyrene foam stops concrete and air entering ends of ribs. Stock length: 1200mm. Required: 300mm per sheet of BONDEK®.



BONSTRIP®
Plastic trim to cover gaps formed by ribs. Used when underside of BONDEK® forms an exposed ceiling. Stock length: 3000mm. Allows plasterboard to be fixed to BONDEK®.

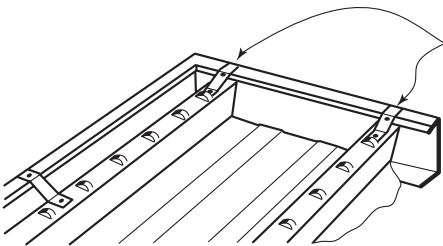


RIB END PLUG (QLD, VIC & NSW)
Polyethylene end plug minimises concrete slurry seeping through.



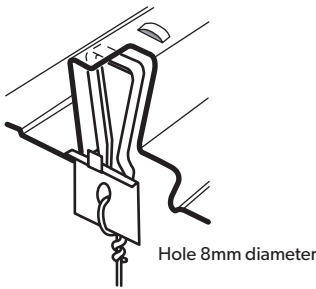
BON-NUT
Heavy duty square nut to suspend ceilings or services. Glued to a paper strip it makes insertion easy. Threads: M8, M10 and M12. M6 is available for light loads only (2.7 kN or less).

BONDEK® BMT	Safe Load
	kN
0.75	4.4
1.00	6.7



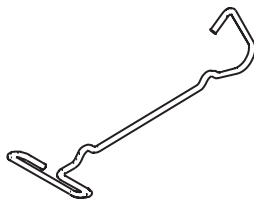
Brackets from builders strapping
Straps formed on-site using builders strapping to secure top flange of the Edgeform.
25mm x 1.0mm fixed with #10-16x16 hex. head Tek screws with drill point. Required: one every 600mm or less if aesthetics are required.

EDGEFORM
A galvanised section that creates a permanent formwork at the slab edges—cut, mitred and screwed on site. 1.0mm BMT - up to 145mm slab depth. 1.2mm BMT - 150 - 175mm slab depth.



BONWEDGE®
Lightweight bracket for rods to suspend ceilings or services (other than fire sprinkler systems). Max. load: 100kg.

Configuration	Loading	Safe Load
		kN
Single BONWEDGE®	Eccentric	1.0
Double BONWEDGE®	Eccentric	1.3
Double BONWEDGE®	Central	1.7



PT HOLD DOWN CLIP
Allows hold down of post-tensioning ducts.

8. References

AS/NZS 1170.0:2002

General principles

AS/NZS 1170.1:2002

Permanent, imposed and other actions

AS 1397:2011

Continuous hot-dip metallic coated steel sheet and strip - Coatings of zinc and zinc alloyed with aluminium and magnesium

AS 1530.4:2005

Methods for fire tests on building materials, components and structures - Fire-resistance tests of elements of building construction

AS 2327.1:2003

Composite structures - Simply supported beams

AS 3600:2009

Concrete structures

AS/NZS 4600:2005

Cold-formed steel structures

AS 3610:1995

Formwork for concrete

AS 3610 Supp 2 :1996

Formwork for concrete - Commentary

Bennetts, I.D., Proe, D., Patrick, M. & Poon, S.L., Composite slabs incorporating BONDEK® II sheeting designed for fire resistance in accordance with AS 3600, Report No. BHP/ENG/R/91/003/PS64R, BHP Research, Melbourne Laboratories, November 1991

EN 1994-1-1:2005

Design Of Composite Steel And Concrete Structures - Part 1-1: General Rules And Rules For Buildings

EN 1994-1-2:2005

Design of Composite Steel and Concrete Structures - Part 1-2: General Rules - Structural Fire Design

EN 1992-1-1:2004

Design of Concrete Structures - Part 1: General Rules and Rules for Buildings

Bennetts, I.D., Filonov, A. A., "Investigation of the behaviour of composite slabs in fire", Australian Structural Engineering Conference, 11-14 September, 2005, Newcastle, Engineers Australia

Appendix A: Material specifications

BONDEK® sheets are readily available, custom-cut, in any length from 600mm up to 19,500mm (length tolerance +0, -10mm) Ask us about longer lengths up to a maximum of 25,000mm. To maximise speed of installation and get better performance, use lengths of BONDEK® that cover multiple spans.

SHEETING

BONDEK® is available in the following gauges base metal thicknesses (BMT) 0.6, 0.75, 0.9* and 1.0mm. It is roll-formed from hot dipped, zinc coated, high tensile zinc hi-ten® steel. The steel conforms to AS 1397, grade G550 and is available in Z350 and Z450* coatings (350g/m² or 450g/m² zinc coating distributed between both sides i.e. 175 or 225g/m² per side).

In special circumstances BONDEK® may be obtained:

- in other base metal thickness
- with non-standard zinc coating mass
- with a pre-painted finish to the underside, called BRITEWHITE®

CONCRETE SPECIFICATION

$\rho_c = 2400\text{kg/m}^3$ (normal density)

See Table A1 for strengths.

Reinforcement specification

- For negative and fire reinforcement D500N grade is used.
- For shrinkage D500L reinforcement is used.

Our design tables assume the use of D500N 12mm diameter bars for negative and fire reinforcement. If you want to use other grades or diameters, run the BONDEK® software. The diameter of reinforcing bars should not exceed 20mm.

SHEAR CONNECTORS

Refer to AS 2327.1 to design composite steel beams.

*Availability is subject to enquiry.

Table A1

Concrete strengths.

Exposure Classification	Minimum concrete compressive strength
A1 & A2	$f_c^1 = 25 \text{ MPa}$
B1	$f_c^1 = 32 \text{ MPa}$
B2	$f_c^1 = 40 \text{ MPa}$

PRODUCT DESCRIPTIONS

- All descriptions, specifications, illustrations, drawings, data, dimensions and weights contained in this catalogue, all technical literature and websites containing information from Lysaght are approximations only. They are intended by Lysaght to be a general description for information and identification purposes and do not create a sale by description. Lysaght reserves the right at any time to:

(a) supply Goods with such minor modifications from its drawings and specifications as it sees fit; and
(b) alter specifications shown in its promotional literature to reflect changes made after the date of such publication.

DISCLAIMER, WARRANTIES AND LIMITATION OF LIABILITY

- This publication is intended to be an aid for all trades and professionals involved with specifying and installing Lysaght products and not to be a substitute for professional judgement.
- Terms and conditions of sale available at local Lysaght sales offices.
- Except to the extent to which liability may not lawfully be excluded or limited, BlueScope Steel Limited will not be under or incur any liability to you for any direct or indirect loss or damage (including, without limitation, consequential loss or damage such as loss of profit or anticipated profit, loss of use, damage to goodwill and loss due to delay) however caused (including, without limitation, breach of contract, negligence and/or breach of statute), which you may suffer or incur in connection with this publication.

© Copyright BlueScope Steel Limited 21 January, 2016

WWW.LYSAGHT.COM

Technical enquiries:

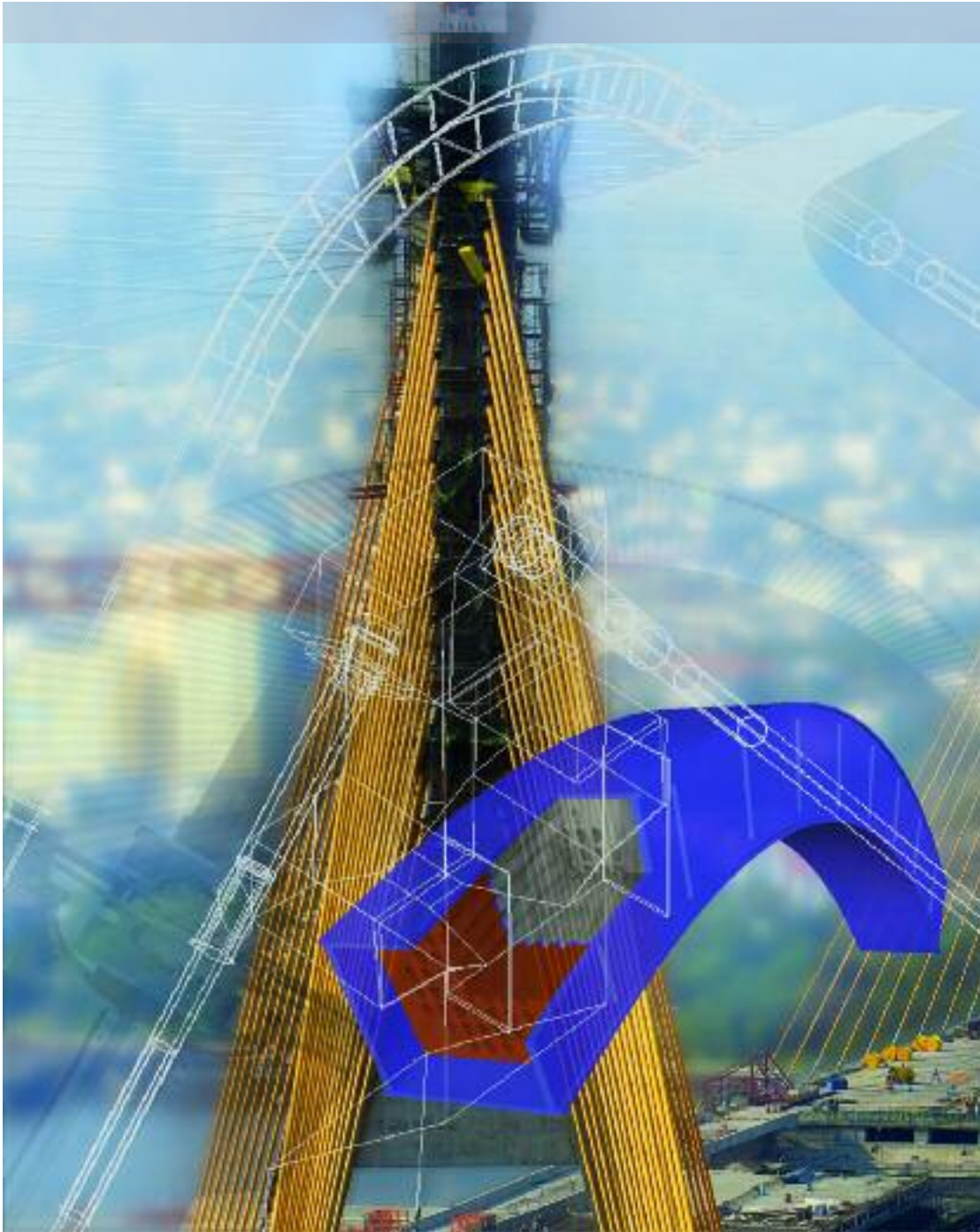
steeldirect@bluescopesteel.com or call 1800 641 417

LYSAGHT®, ZINCALUME®, BONDEK®, BONFILL®, BONWEDGE®, BONSTRIP®, BRITWITE®, DECKFORM® and BlueScope® are registered trademarks of BlueScope Steel Limited, ABN 16 000 011 058. The LYSAGHT® range of products is exclusively made by or for BlueScope Steel Limited trading as Lysaght.



LYT0014 21.01.16

VSL SSI 2000 STAY CABLE SYSTEM



DESIGN
ENGINEERING
SUPPLY
INSTALLATION
MONITORING

VSL – LEADING IN STAY CABLE TECHNOLOGY

Industrial Ring Road – Bangkok, 2008

VSL – a worldwide network

From concept to site works, the VSL network of locally operating units adds value throughout all stages of a project by providing fully-customised solutions, developed and implemented by highly-trained and experienced staff working in close partnership with clients. Customers have access to a local partner, while benefiting from global resources, know-how and expertise as well as VSL's continuing development of specialist construction techniques.

VSL – a commitment to quality, safety and sustainable development

VSL pursues a strong quality, safety and sustainable development policy in keeping with its leading position as a specialist contractor. Proactive management systems have been

established to address local needs while ensuring a high common standard throughout the company network.

VSL recognises that its employees are the key to competitiveness, efficiency and safe working practices. The company is committed to "Safety First" and strives for "Zero Accident" by motivating and empowering its employees to act responsibly in order to achieve these goals.

VSL – a specialist stay cable contractor

As leader in stay cable technology, VSL offers the solutions to tackle today's challenges in cable-stayed construction and develops the next-generation systems in close collaboration with its clients. The recent boom in cable-stayed bridges with considerably increased

spans and cable lengths calls for faster erection cycles and increases the dynamic demands on the stay cables. VSL's lightweight erection equipment, compact strand bundle solutions and its highly-efficient and reliable damping systems lead the way in meeting today's needs.

Its vast experience led VSL to launch the SSI 2000 system, which has been installed very successfully on more than 100 projects in recent years. VSL's latest developments extend the SSI 2000 range to provide even greater flexibility for a multitude of applications, while maintaining the system's proven outstanding performance. VSL's portfolio is now well over 150 cable-stayed bridges.



CREATING SUSTAINABLE SOLUTIONS TOGETHER



Designed to last

VSL Stay cables have a design life of 100 years even in the most aggressive environments. Elements are fully replaceable without requiring modifications to the structure. All the materials used have been carefully selected and all components have been detailed to meet the highest durability criteria. In addition, the modular nature of the VSL SSI 2000 Stay cable system helps reduce the environmental impact of maintenance operations by minimising the amount of waste generated when parts have to be replaced during the structure's life cycle.

New VSL developments in stay cable technology

SSI Saddle, a patented design facilitating simplified pylon layouts resulting in enhanced bridge aesthetics and increased structural efficiency

SSI 2000-C, a compact stay cable system with reduced cable diameter and therefore reduced wind drag

SSI 2000-D, a stay cable protected against corrosion by dehumidification techniques - a patented solution offering the smallest cable diameters available in strand technology and minimising wind drag while fully maintaining the advantages of strand-by-strand replacement

A choice of two damping systems to control cable vibrations efficiently, adapted to the characteristics of the structure

Modern engineering to stringent standards

Designers, owners and authorities are demanding:

- Increased long-term performance of stay cables, tensile members and anchorages; leak-tightness of the anchorage assembly; easy inspection and maintenance; the capability to replace cables with minimal interruption to bridge traffic; and reliable control of cable vibrations
- Minimal wind drag for long spans
- Outstanding static and fatigue behaviour, validated by performance testing
- Incorporation of damping systems at the time of installation or as part of dynamic retrofitting
- Improved aesthetics by using compact anchorages, saddles and coloured cables

Main contractors seek:

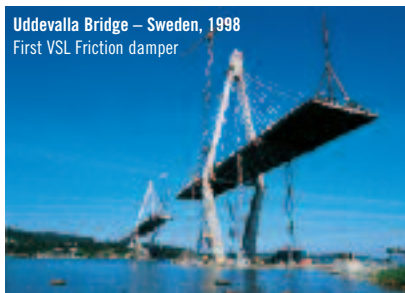
- Simple interfaces between deck erection and stay cable installation with a reduced number of activities on the critical path
- Lightweight installation equipment, facilitating a flexible erection schedule that separates deck and pylon construction from the stay cable erection works and minimises the crane time required

Owners benefit from:

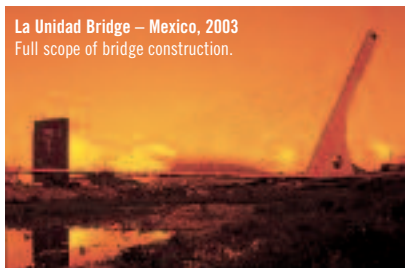
- Enhanced durability
- Substantial savings on maintenance

The VSL SSI 2000 Stay cable system is designed to meet the requirements and applicable specifications issued by *fib* (International Federation for Structural Concrete), PTI (Post-Tensioning Institute) and CIP (Commission Interministérielle de la Précontrainte).

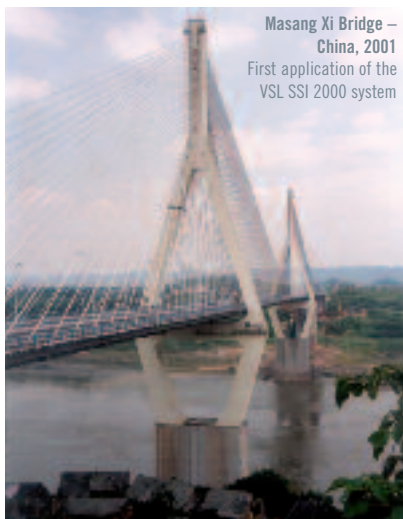
Uddevalla Bridge – Sweden, 1998
First VSL Friction damper



La Unidad Bridge – Mexico, 2003
Full scope of bridge construction.



Masang Xi Bridge – China, 2001
First application of the VSL SSI 2000 system



SSI 2000: VSL STAY CABLE TECHNOLOGY

Compact anchorage

Fully prefabricated including its corrosion protection in controlled factory conditions

Several complementary barriers

For complete water tightness of the anchorage

Anchorage protection cap with flexible gel filler

Strands encapsulated by a polymerised and bonded filler, achieving reliable corrosion protection while allowing access for inspection if necessary

High fatigue resistance

Demonstrated in fatigue tests in accordance with *fib* and PTI requirements under combined tensile and bending action

Replaceable strand system in a durable stay pipe

Sheathed, greased or waxed strands with optional galvanization, protected in an HDPE pipe with proven ageing performance. Each strand can be individually monitored, inspected and replaced

Individual encapsulation and deviation

Each strand is individually protected with a multi-layer barrier system inside a leak-tight anchorage assembly and is separately guided to filter bending stresses at the anchorage entrance

The SSI 2000 Stay cable system is based on VSL's proven strand technologies

The SSI 2000 wedge anchorages and its tensile members as well as its protective system meet the most stringent requirements for durability, tensile capacity and fatigue performance. Its strand-by-strand technology ensures maximum flexibility and full capability for replacement.

High fatigue performance

The anchorage assembly is designed to control the deviation of individual strands and to filter cable vibrations outside the wedge anchorage zone. Its outstanding fatigue performance has been demonstrated in fatigue tests as specified in the latest recommendations by PTI and *fib* with imposed angular deviation of the

anchorage from the cable axis. A tension ring or a guide deviator can be used to bundle the strands at the exit of the guide pipe.

Durability and multi-barrier protection

All SSI 2000 stay cables are engineered for a design life of 100 years in the most aggressive environments.

The unique feature of individual encapsulation of each strand within the anchorage assembly eliminates the risk of corrosion migration between strands.

The multi-barrier protection system is achieved in the free length by individually sheathed, greased or waxed strands with optional galvanization

within the protective outer stay pipe. The protection is maintained in the anchorage assembly by a flexible gel filler injection, which has passed the stringent leak-tightness tests specified by PTI and *fib*.

Cable installation with lightweight equipment and minimum impact on other erection activities

The compact nature of the anchorages and the strand-by-strand installation with lightweight equipment frees tower crane time and does not require any heavy deck equipment. Therefore, the stay installation does not impair the key activities in a typical deck and pylon construction cycle.

Free tension ring

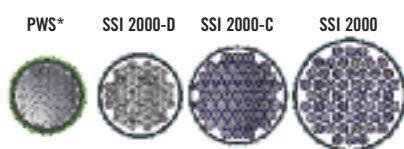
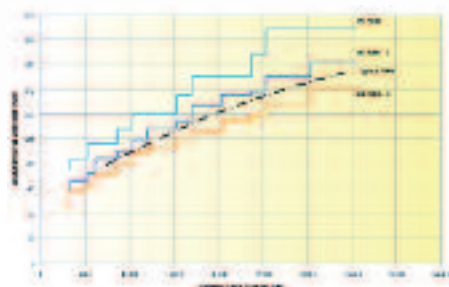
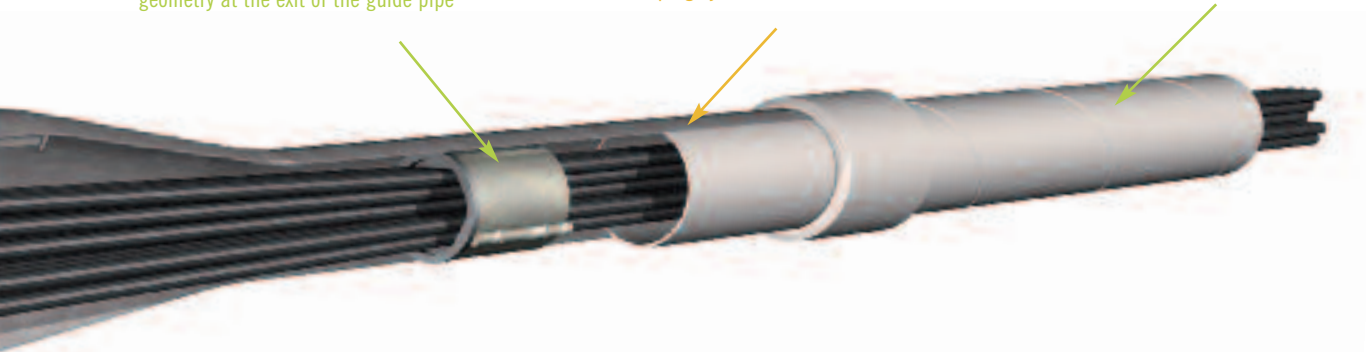
Located inside the stay pipe. Can be replaced by a guide deviator, depending on the geometry at the exit of the guide pipe

Anti-vandalism protection

Designed to protect the stay cable above deck level and to accommodate an optional damping system

Low drag coefficient and aeroelastic stability

External helical ribs tested in wind tunnel for efficient control of rain-wind induced vibrations. Two options for even lower wind drag – SSI 2000-C and SSI 2000-D with reduced stay pipe diameters



Comparison of equivalent drag diameter of different types of stays

Equivalent Drag Diameter = O.D. Stay Pipe x Drag Coefficient C_d
 $C_d = 0.6$ for SSI 2000 has been determined in wind tunnel testing

$C_d = 0.8$ for PWS is based on typical project specification

* PWS = typical parallel wire system

Cable replacement strand by strand with minimum traffic disruption

Strands can be individually monitored, inspected and replaced: entire cables can be replaced strand by strand. The use of lightweight equipment minimises the impact on vehicular traffic and cable replacement can be achieved under single lane closures.

VSL Dampers

The stay cable can be designed with two types of dampers, the VSL Friction damper or the VSL VE damper, or provision can be made for later installation.

SSI Saddle with fully replaceable strands

For extradosed bridges and cable-stayed bridges with compact pylon arrangements, VSL offers a patented saddle solution compatible with the SSI 2000 system. The compact saddle design allows for strand-by-strand installation and replacement and achieves a safe and reliable anchorage for unbalanced cable loads. Extensive fatigue testing has been carried out in accordance with *fib* requirements to demonstrate that there is equivalent performance between saddle and standard anchorages.

Three systems are available to meet project-specific aerodynamic requirements.

The standard SSI 2000 system with an optimised stay pipe to control rain-wind induced vibration and minimise wind drag

The stay pipe is fitted with a continuous helical rib, effectively suppressing rain and wind induced vibrations and reducing the wind drag on the cable. Extensive wind tunnel testing at speeds of up to 70m/s has been carried out for validation.

SSI 2000-C: the VSL compact system for long cables

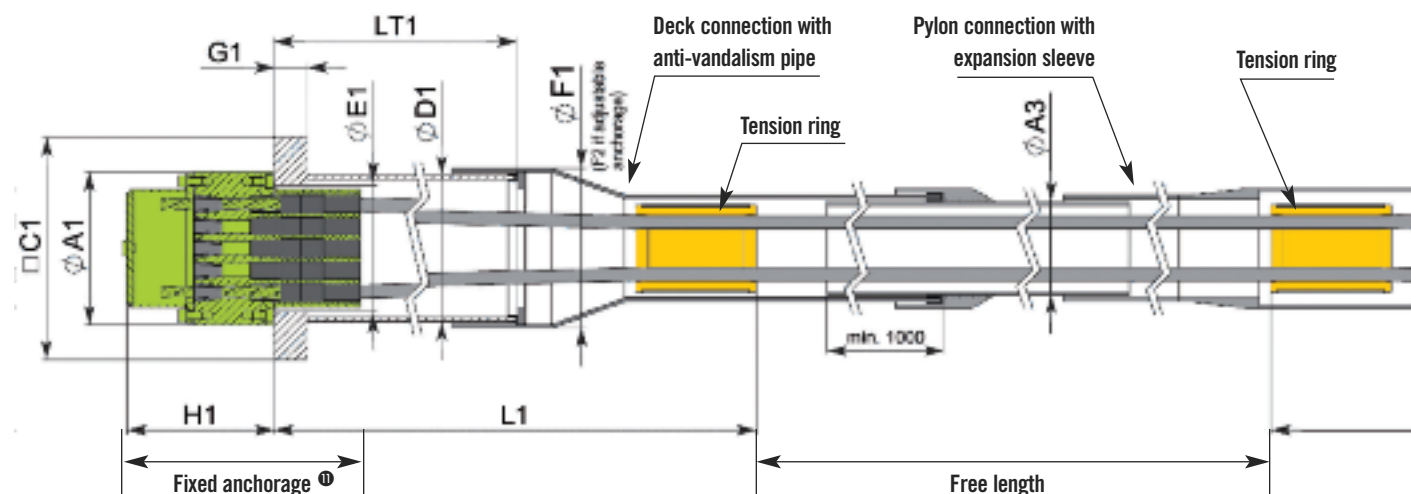
Reduced stay pipe diameters result in lower wind drag on the stay cable and hence in a reduction of wind loads on the structure. This can be an important parameter in the design of long-span bridges. The SSI 2000-C compact stay cable range offers significantly reduced stay pipe diameters for the same permissible cable load. While this is the system of choice for exceptionally long cables, special tools are required for its installation.

SSI 2000-D: the VSL dehumidified system for even lower wind drag

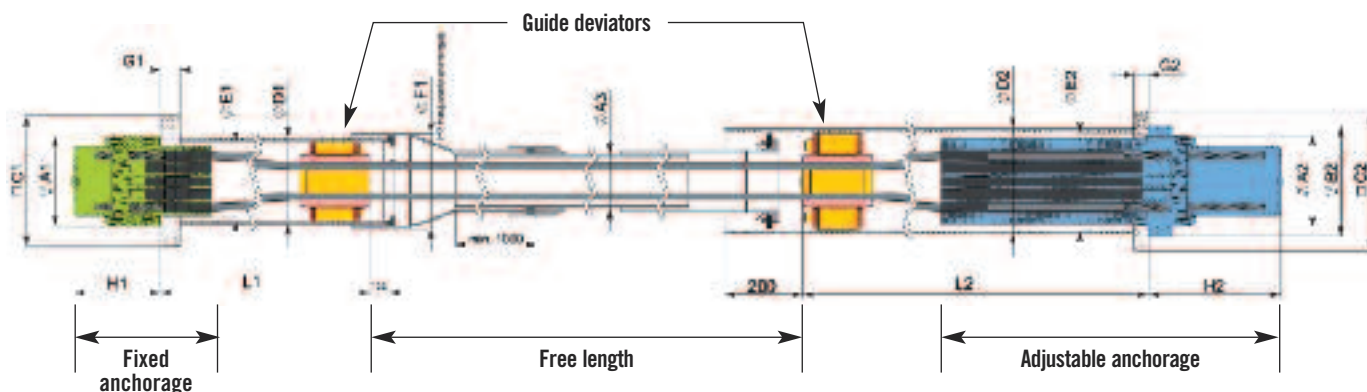
The system maintains all the proven features of the standard anchorage system, while reducing further the cross section of the ducted strand bundle by eliminating the sheathing of the strands and providing equivalent corrosion protection through permanent dehumidification of the cable. The result is the most compact parallel strand stay cable on the market – a system with fully replaceable individual strands and unrivalled low wind drag.

VSL SSI 2000 MAIN DIMENSIONS

STANDARD ARRANGEMENT WITH TENSION RING



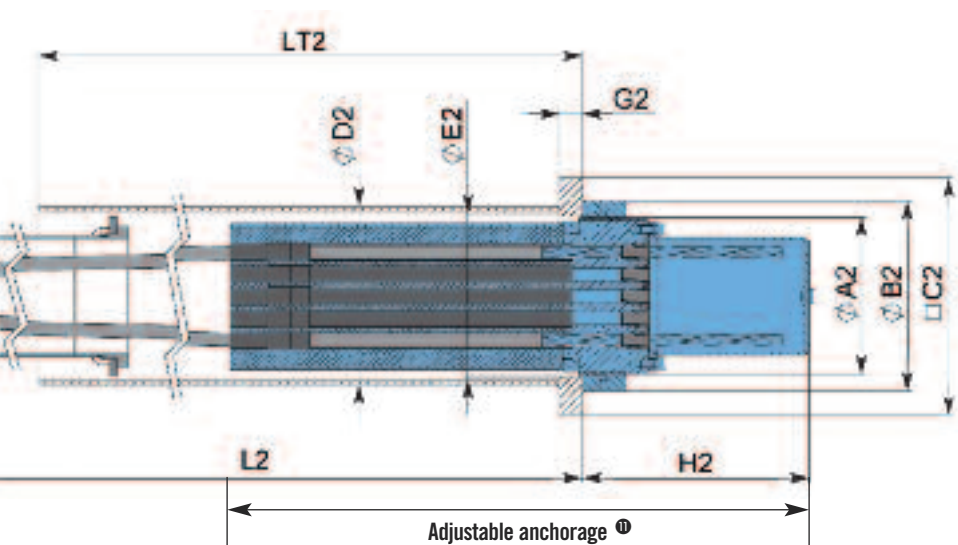
ALTERNATIVE ARRANGEMENT WITH GUIDE DEVIATOR



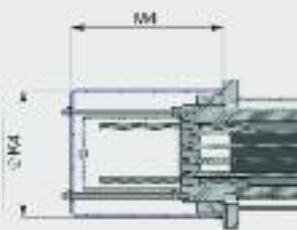
CABLE UNIT ③	NUMBER OF STRANDS	STAY			STAY PIPE		
		BREAKING LOAD AT 100% GUTS kN ①	ADMISSIBLE LOAD AT 50% GUTS kN ②	ADMISSIBLE LOAD AT 60% GUTS kN ③	SSI 2000 mm ④	SSI 2000-C ØA3/thk mm ④	SSI 2000-D mm ⑤
6-12	12	3,348	1,674	2,009	125/4.9	95/5.0	80/5.0
6-19	19	5,301	2,651	3,181	140/5.4	110/5.0	95/5.0
6-22	22	6,138	3,069	3,683	160/5.0	120/5.0	105/5.0
6-31	31	8,649	4,325	5,189	160/5.0	140/6.0	120/6.0
6-37	37	10,323	5,162	6,194	180/5.6	150/6.0	130/6.0
6-43	43	11,997	5,999	7,198	200/6.2	165/6.0	145/6.0
6-55	55	15,345	7,673	9,207	200/6.2	180/6.0	155/6.0
6-61	61	17,019	8,510	10,211	225/7.0	190/6.0	165/6.0
6-73	73	20,367	10,184	12,220	250/7.8	210/6.6	175/6.0
6-85	85	23,715	11,858	14,229	250/7.8	225/6.9	190/6.0
6-91	91	25,389	12,695	15,233	280/8.7	230/7.2	200/6.2
6-109	109	30,411	15,206	18,247	315/9.8	250/7.7	215/6.7
6-127	127	35,433	17,717	21,260	315/9.8	270/8.4	235/7.3
6-139	139	38,781	19,391	23,269	315/9.8	- ⑥	- ⑥
6-151	151	42,129	21,065	25,277	355/11.1	- ⑥	- ⑥
6-169	169	47,151	23,576	28,291	355/11.1	- ⑥	- ⑥
6-187 ⁸	187	52,173	26,087	31,304	400/12.3	- ⑥	- ⑥

FIXED ANCHORAGE						
ØA1	C1	ØD1/thk	ØE1	ØF1	G1	H1 mini
mm	mm ⑥	mm/mm	mm	mm	mm	mm
185	260	177.8/4.5	150	190	35	205
230	335	219.1/6.3	190	233	50	220
250	355	219.1/6.3	205	233	50	220
280	415	244.5/6.3	230	260	60	245
300	455	273/6.3	255	286	70	270
340	505	323.9/7.1	285	337	75	275
380	550	323.9/7.1	310	337	75	295
380	585	355.6/8	330	370	85	310
430	650	406.4/8.8	370	420	95	330
430	685	406.4/8.8	370	420	110	360
480	730	457/10	420	470	110	370
495	775	457/10	420	470	120	380
550	845	508/11	475	525	130	430
570	900	520/12	480	540	135	440
590	920	559/12.5	490	550	140	460
630	970	585/14	510	580	150	480
660	1,000	600/15	550	620	160	490

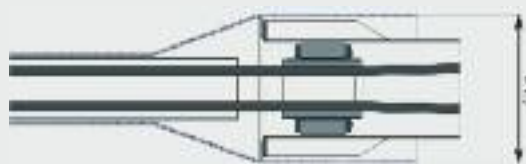
- ① Based on strand specification as per EN 10138 (150mm², 1860MPa); reduction required for ASTM A416 or BS 5896; GUTS = Guaranteed Ultimate Tensile Strength of strand
 ② Recommended max. service stress for stay cables as per fib bulletin No. 30 and CIP
 ③ Recommended max. service stress for extradosed cables as per CIP
 ④ Galvanized and sheathed strand with a minimum sheathing thickness of 1.5mm



OPTIONAL ITEMS



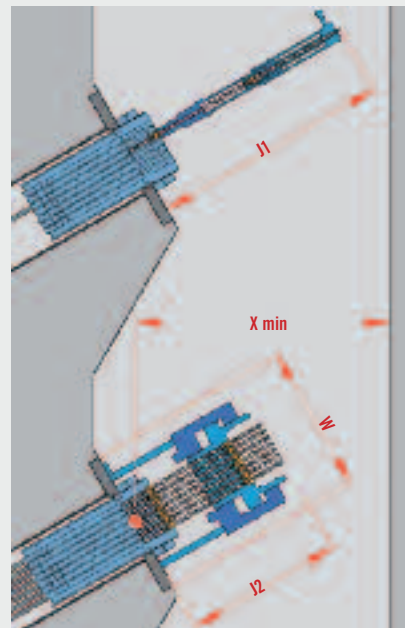
Optional anchorage cap
for adjustable anchorage in severe environments class C5-M and -I as per ISO 12944



Optional anti-vandalism pipe
for future provision of damper

Required clearances

In case of facing adjustable anchorages, it is recommended to provide two times the minimum clearance. If reduced clearances are required, please contact VSL.



Required jack clearances

ANCHORAGE UNIT	W mm	J1 mm	J2 mm	Xmin mm
6-12 to 6-19	490	1,000	1,000	1,500
6-22 to 6-43	620	1,050	1,100	1,500
6-55 to 6-73	780	1,100	1,200	1,500
6-85 to 6-91	780	1,150	1,300	1,500
6-109 to 6-127	970	1,200	1,500	1,800
6-139 to 6-187	- ⑨	1,250	- ⑨	2,000

ADJUSTABLE ANCHORAGE						
ØA2	B2	C2	ØD2/hk	E2	G2	H2 mini
mm	mm	mm ⑥	mm/mm	mm	mm	mm
190	230	290	219.1/6.3	196	30	320
235	285	355	267/6.3	241	35	345
255	310	385	298.5/7.1	261	40	355
285	350	440	323.9/7.1	291	45	405
310	380	485	355.6/8	316	50	435
350	425	540	406.4/8.8	356	55	450
385	470	585	419/10	391	60	490
385	470	600	419/10	391	65	525
440	530	680	508/11	446	75	525
440	540	710	508/11	446	80	585
490	590	760	559/12.5	496	80	580
505	610	795	559/12.5	511	90	615
560	670	865	610/12.5	566	95	665
580	700	910	630/15	590	100	685
590	720	940	640/15	600	100	695
630	760	1,000	685/15	640	110	730
660	800	1,050	720/15	670	120	770

DEVIATED LENGTH	
L1	L2
mm	mm
1,100	1,500
1,370	1,770
1,550	1,950
1,740	2,140
1,920	2,320
2,170	2,570
2,290	2,690
2,490	2,900
2,710	3,120
2,830	3,240
3,080	3,490
3,230	3,640
3,630	4,030
3,680	4,090
3,770	4,170
4,180	4,580
4,190	4,590

STANDARD ARRANGEMENT			
LT1 DECK	LT1 PYLON	LT2 DECK	LT2 PYLON
mm ⑦	mm	mm ⑦	mm
500	500	1,000	1,000
500	500	1,000	1,000
500	500	1,000	1,000
500	900	1,000	1,200
500	900	1,000	1,200
500	900	1,000	1,200
500	1,100	1,000	1,400
500	1,100	1,000	1,400
500	1,100	1,000	1,400
500	1,300	1,000	1,600
500	1,300	1,000	1,600
500	1,300	1,000	1,600
500	2,000	1,000	2,000
500	2,000	1,000	2,000
500	2,000	1,000	2,000
500	2,200	1,000	2,500
500	2,200	1,000	2,500

ALTERNAT.
HORIZONTAL FORCE ON GUIDE DEVIATOR kN ⑩
50
80
92
130
155
180
230
255
306
356
381
456
531
582
632
707
783

OPTIONAL DETAILS		
ØF4	ØK4	M4 MINI
mm	mm	mm
430	240	380
450	300	400
470	320	410
505	360	460
545	390	490
585	440	510
610	490	550
630	490	580
650	550	580
680	560	640
700	610	640
730	630	670
740	690	700
- ⑨	- ⑨	- ⑨
- ⑨	- ⑨	- ⑨
- ⑨	- ⑨	- ⑨
- ⑨	- ⑨	- ⑨

⑤ Galvanized strand in accordance with NF A 35-035

⑥ Square bearing plate based on concrete strength of 45MPa cube (36MPa cylinder); dimensions can be adjusted for other concrete strength or steel structures

⑦ Can be reduced if required; please contact VSL

⑧ Larger units available on request

⑨ Dimensions available on request

⑩ SLS Level

⑪ Fixed or adjustable anchorages are interchangeable between pylon and deck, see dimensions L1 and L2

DURABLE DESIGN BACKED UP BY THOR

Durability and fatigue resistance are of utmost importance for stay cables, together with accessibility of components and monitoring of the structure.



Wind tunnel testing

Designed to last

VSL Stay cables have a design life of 100 years in the most aggressive environments, as defined by the C4 and C5 categories of the ISO 12944 standard. All elements are fully replaceable without requiring modifications to the structure. All the materials used have been carefully selected and all components detailed to meet the highest durability criteria. The SSI 2000 performance even exceeds the stringent durability requirements provided in the relevant recommendations from PTI and CIP. All non-accessible components are supplied with a factory-applied protection system ensuring a 100 year design life without maintenance. The accessible and replaceable elements are designed for a 25 year maintenance interval. The main tensile element of the cable, consisting of VSL-specified strands, is designed with a multi-layer protection system to match the performance of the anchorages. VSL provides a detailed

maintenance schedule for each project and can assist clients in the implementation.

Leak-tightness testing for anchorages

The anchorage is the most vulnerable part of a modern stay cable in terms of durability. In order to achieve a continuously protected transition from the free length of the cable into the anchorage zone, it is important to prevent water ingress through the component interfaces, particularly at the lower deck anchorage.

VSL has equipped its anchorages with a redundant multi-layer sealing system, which has passed the leak-tightness tests as defined by PTI and *fib*.

Accelerated ageing tests for coloured stay pipes

Correct material selection and manufacturing control is important to avoid variations in the characteristics of the HDPE components used for the outer protection layers of the free length. Ageing effects, UV radiation and/or pollution can deteriorate the condition of the stay pipe over time.

The evolution of the mechanical and colorimetric properties is verified by performing accelerated ageing tests.

With a focus on durability throughout all phases, VSL has developed specialist methods and procedures to ensure that the required installation quality is achieved and that any damage that might occur to the components during transportation, handling or installation is detected and rectified prior to project delivery. The modular nature of the system allows for simple replacement of any damaged parts without critical delay to the installation schedule.



Tensile test on an HDPE stay pipe sample after accelerated ageing



Fatigue test through 2 million cycles



Inspection of a 6-37 anchorage after a leak-tightness test. While being subjected to mechanical and environmental stresses, the anchorage is immersed in a dye solution with a pressure head of 3m.

OUGH TESTING

Fatigue testing

The fatigue performance of the VSL Stay cable system has been demonstrated in many fatigue tests in accordance with PTI and *fib* recommendations with stress ranges of 200MPa at 45% GUTS upper stress over two million cycles and a 10mrad deviation at the anchorages.

Proven technology for protecting the SSI 2000-D

With the SSI 2000-D system, VSL introduces proven dehumidification technology to stay cables, defining a new standard for the industry (see page 10). The D system maintains the highest standards of durability while eliminating the need for individual sheathing of the strands and hence allowing a significant reduction in cable diameters (see page 10).

Equivalent durability using an injected saddle with replaceable strands

The SSI Saddle is the first saddle in the market with injected but replaceable strands. The PE sheathing is removed from the strand at the saddle location. Each strand is individually guided through the saddle and injected with a bonded, flexible gel filler, effectively preventing any oxygen or corrosive agents from reaching the strand. Full-scale fatigue tests have demonstrated that the saddle fulfils the same fatigue criteria as the standard anchorages and that no fretting corrosion occurs.

Durability requirements for stay cables

- The *fib* stay cable recommendations specify a design life of 100 years for stay systems installed in bridge structures and emphasise the need for adequate maintenance.
- The CIP stay cable recommendations propose a design life of 50 years for replaceable systems and 100 years for non-replaceable systems and require defined maintenance intervals



Red color stay pipes
(Sucharskiego Bridge, Poland)



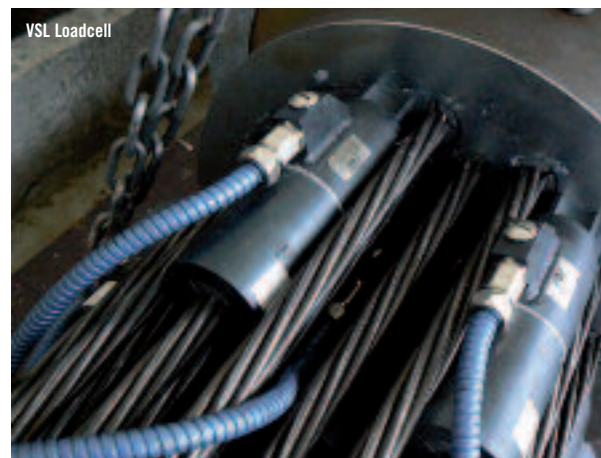
White color stay pipes
(Neva Bridge, Russia)



Gold color stay pipes
(Industrial Ring Road, Bangkok)



VSL Saddle testing



VSL Loadcell

Enhanced durability by systematically controlling vibrations

VSL offers two types of dampers for effective control of the cable vibration: the VSL Friction damper and the VSL VE damper. Both dampers can either be installed during construction or retrofitted on existing structures. The dampers are designed for maximum durability by minimising the number of moveable parts and selecting the most durable materials.

VSL structural monitoring solutions

VSL also offers structural monitoring packages. Sensor solutions for permanent or temporary load and deformation measurements on cables can be combined with instrumentation of the structure. This allows collection of all the necessary data to optimise maintenance, validate design assumptions, diagnose mechanisms of deterioration and detect damage at an early stage.

THE VSL SSI 2000-D SYSTEM*

The world's most compact stay cable strand protected by dry air

Protection cap with inspection window

Not injected hence allowing permanent visual inspection of the anchorage's condition without the need for dismantling.

Reduced cost for any cable replacement

Non-sheathed strands

Standard guide pipe

internally protected by the dry air system

Sensors

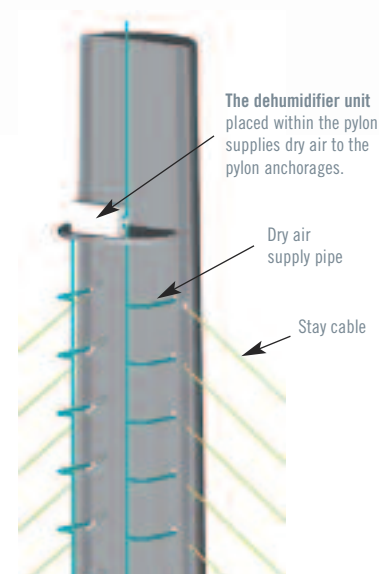
for permanent monitoring of corrosion-critical parameters

- temperature
- humidity
- air pressure

A compact bundle of unsheathed strands protected by dry air

With the SSI 2000-D system, VSL offers the most compact parallel strand stay cable in the market. The resulting wind drag is lower than that of parallel wire cables with equivalent capacity, while the system maintains all the typical SSI 2000 benefits when it comes to installation, inspection and replacement.

The galvanised, unsheathed strands are placed inside an air-tight enclosure, where optional dampers can also be accommodated. A dehumidifier unit, typically placed inside the pylon, provides a constant supply of dry air at the pylon anchorages, while maintaining a permanent pressure differential between the inside and the outside of the cable. This prevents any ingress of moisture or other corrosive agents from the outside. All structural elements of the stay cable are



* patent pending



Air-tight seal protected by anti-vandalism pipe
against UV radiations

Co-extruded or full-coloured HDPE stay pipe
Outer protective barrier with helical ribs

Reduced cable diameters
Strand cable with the lowest outer diameter for smallest wind drag

VSL Friction or VE damper
fully protected by dry air where installed

Redundancy and equivalent corrosion protection

The principle of multi-barrier protection remains unchanged even though the SSI 2000-D does not make use of individually sheathed strands:

- the stay pipe provides an airtight enclosure, protecting the tensile element against environmental effects
- a protective environment of dry air around the strands prevents moisture and corrosive agents from reaching the strands
- continuous galvanisation of the bare strand provides a final barrier against corrosion in case of scheduled removal or accidental loss of the other two barriers.

protected within this controlled environment where the humidity is maintained below the threshold that would trigger corrosion.

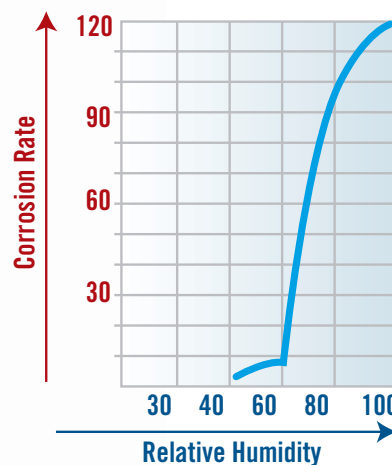
The applied pressure differential ensures that a leak in the system will only result in an increased air demand and will not jeopardise the protective mechanism.

Dry air – a reliable and proven solution

The concept of dehumidification systems to protect steel bridge decks and suspension cables was introduced in the 1970s and is today a well understood and highly reliable solution, applied to some of the most prestigious bridges around the world.

With the SSI 2000-D system, VSL has applied this proven technology to stay cables to offer a state-of-the-art corrosion protection solution.

Use of the latest dehumidification equipment keeps operational and maintenance costs extremely low. Running cost estimates can be provided on request.



Iron Corrosion Rate at different Relative Humidities (%RH)

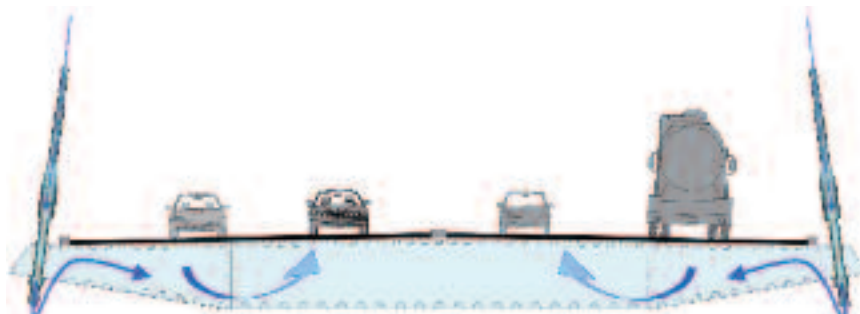
humidity inside the cable together with the air pressure. In addition, the protective caps at the anchorages can be fitted with transparent windows allowing a simple visual inspection of the anchorage condition. This significantly reduces the time and cost involved in periodic inspections of the anchorage components.

Combining cable and deck protection

Where the SSI 2000-D is used with steel bridge decks or pylons with closed cross section, the dehumidification can protect both the stay cables and the structural steel elements by suitable sizing of the dehumidification units.

Permanent monitoring of the corrosion protection

The integrity of the corrosion protection system can be monitored permanently through continuous measurement of the corrosion-critical parameters of temperature and



The dry air combined protection

THE VSL SSI SADDLE

VSL has developed a new generation of stay cable saddles combining the advantages of injected saddles with full strand-by-strand installation and strand-by-strand replacement.

Saddles are the solution of choice for many bridges when it comes to compact and slender pylon designs or for extradosed structures. Replacing a pair of pylon anchorages with a single saddle simplifies the detailing and eliminates the need to anchor large splitting forces in the pylon.

The benefits of saddles are widely accepted but their general use had been prevented in the past by the issues of reduced fatigue performance compared to anchorage, the risk of fretting corrosion and the inability to replace single strands.

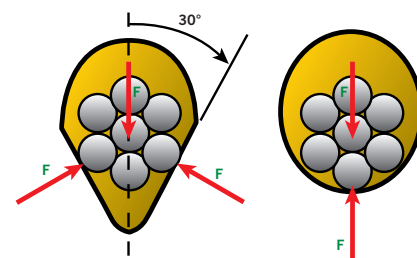
VSL responded to these challenges with the SSI Saddle. Individual guiding and encapsulation of the strands allows strand-by-strand installation, inspection and replacement. Injecting the guide tubes with a special, polymerised and bonded flexible gel filler prevents any ingress of oxygen, hence eliminating the risk of fretting corrosion. The result is a saddle with fully replaceable strands that achieves the same fatigue performance as standard SSI 2000 Anchorages.

The V-effect: maximum friction using wedge action

The SSI Saddle is a steel box filled with Ductal® ultra-high-performance concrete and featuring V-shaped guide voids for each individual strand. This patented geometry provides an efficient wedge action, continuously gripping the strand by friction along the deviated length, while minimising fretting under cyclic loading. The entire saddle is detailed such that the deviation occurs entirely in the strand-to-Ductal® interface with no intermediate layers that could deteriorate over time.

Independently guided and replaceable strands

The VSL Saddle allows unrivalled single strand installation, inspection and replacement. Strands can be individually stressed and de-stressed. In the same way that larger anchorage units can have spare strand positions, the saddle can also incorporate additional guide voids to give the option for a future increase in cable capacity.



SSI Saddle section, with the "V" shaped strand hole compared to circular guide void

Seamless integration with the SSI System

The VSL Saddle uses the same strand as the standard SSI 2000 System, with no additional treatment required. The removal of the tightly extruded PE-coating on the deviated length inside the saddle is performed on site.

Continuous multi-barrier corrosion protection

The PE-coating of the strands is removed inside the deviated length of the saddle to achieve strand-to-Ductal® contact. As with the other SSI components, multi-barrier protection has been incorporated:

- An outer casing consisting of a steel box and Ductal® gives protection against ingress of water and corrosive agents
- Injection of the guide voids with a polymerised, bonded, flexible gel filler gives a reliable seal against moisture and oxygen
- Galvanisation of the strand provides protection during the installation period prior to the injection

Transfer of high differential cable forces into the pylon

Unbalanced loading between bridge spans results in a need to transfer differential cable forces to the pylon, which is achieved by high friction in the V-shaped guide voids in the saddle. Consistent friction coefficients in excess of 0.4 are attained in tests.



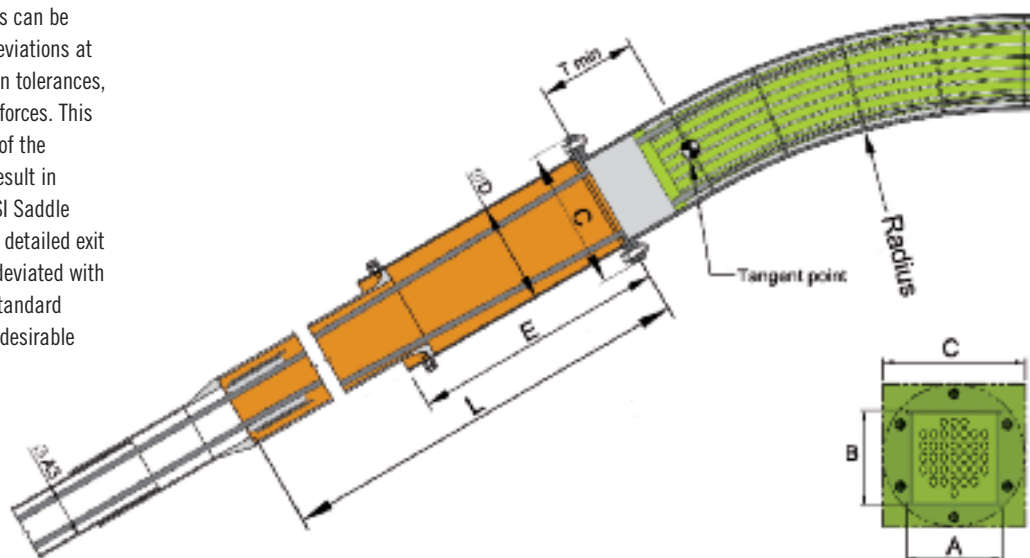
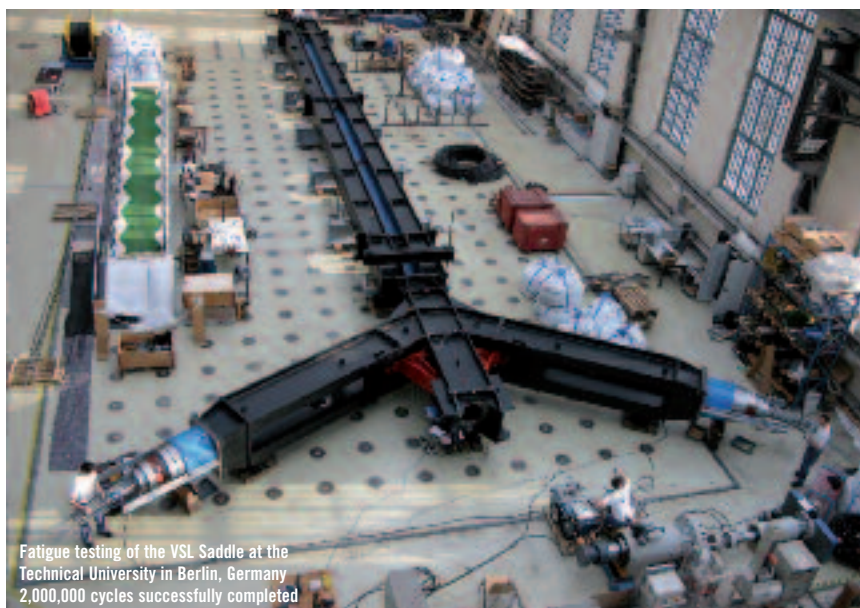
VSL Saddle design with cable connection

Proven fatigue performance

VSL has carried out extensive fatigue testing with the SSI 2000 Saddle in accordance with *fib* recommendations, including a full scale test using a 6-55 unit.

Controlled filtering of angular deviations at the saddle exit

Stay cable anchorages and saddles can be subjected to significant angular deviations at their exits as a result of installation tolerances, vibrations and variations in cable forces. This could cause gradual deterioration of the protective layers of the strand or result in premature fatigue damage. The SSI Saddle avoids this by incorporating a well detailed exit where each strand is individually deviated with the same characteristics as in a standard anchorage, without introducing undesirable stress into the pylon surface.



Main dimensions (using VSL SSI 2000)

CABLE UNIT	STAY			STAY PIPE CONNECTION				SADDLE BODY			
	NUMBER OF STRANDS	BREAKING LOAD AT 100% GUTS MPa	MAX. RADIAL BEARING STRESS AT 2.4m RADIUS	L	E	ØD	ØA3/thk.	C	B	A	T min
	kN			mm	mm	mm	mm	mm	mm	mm	mm
6 - 12	12	3,348	9	1,160	250	193.7 / 4.5	125 / 4.9	320	200	185	300
6 - 19	19	5,301	11	1,760	250	244.5 / 5	140 / 5.4	370	235	230	300
6 - 22	22	6,138	13	1,900	500	244.5 / 5	160 / 6.2	370	235	230	300
6 - 31	31	8,649	13	2,220	500	273 / 5	160 / 6.2	400	275	300	300
6 - 37	37	10,323	15	2,580	500	323.9 / 5.6	180 / 5.6	450	310	310	300
6 - 43	43	11,997	14	2,540	500	355.6 / 5.6	200 / 6.2	500	310	375	300
6 - 55	55	15,345	18	2,880	800	368 / 6	200 / 6.2	510	350	380	300
6 - 61	61	17,019	20	3,240	800	406 / 6.3	225 / 7	550	395	410	300
6 - 73	73	20,367	20	3,470	800	430 / 8	250 / 7.8	570	395	470	300
6 - 85	85	23,715	23	3,590	800	450 / 8	250 / 7.8	590	430	480	300
6 - 91	91	25,389	23	4,010	800	480 / 8	280 / 8.7	620	470	520	300
6 - 109	109	30,411	24	4,120	800	500 / 8	315 / 9.8	640	470	580	300
6 - 127	127	35,433	26	4,700	800	560 / 8	315 / 9.8	700	545	580	300

VSL SOLUTIONS FOR CABLE VIBRATION

VSL provides expertise to assist owners and designers in analysing the risks of cable vibrations and proposes appropriate mitigation measures.

The mechanisms of dynamic excitation of stay cables are complex and can only be partially addressed in the various general recommendations for cable-stayed structures. VSL applies various stability criteria to estimate the risks of unacceptable cable vibration in order to determine the structural and additional damping requirements. The VSL Stay cable system offers a modular approach for mitigating the risks of cable vibrations.

Helical ribs

The outer stay pipe is fabricated with double helical ribs, which have been optimised in wind tunnel tests for maximum efficiency and minimum drag against vibrations induced by rain and wind.

Two different types of dampers

VSL offers two damping solutions for stay cables: the VSL Friction damper and the VSL VE damper. Both are highly efficient as well as extremely durable and require little maintenance. The outstanding long-term performance is based on minimising the



VSL Friction damper



VSL Friction damper – high performance for critical cases

High efficiency: Several comparative tests on full-scale cables fitted with dampers have demonstrated the exceptional efficiency of the VSL Friction damper. The performance has repeatedly exceeded the specified requirements.

Outstanding durability: The friction damper achieves an excellent long-term performance by being designed to work only when needed. It comes into action once the displacement reaches a level that is considered critical for the cable's performance. Once activated, the damper achieves its maximum damping effect immediately.

Aesthetic solution: The installation of damping systems on stay cables has to be carried out with minimum impact on the visual appearance of the structure. The addition of external damper supports is often undesirable and the compact nature of the friction damper allows it to be fully integrated into the anti-vandalism pipe of the SSI 2000 System.

Other benefits of the VSL Friction damper:

- Easy access for simplified inspection and maintenance
- Tuning of the damping performance by adjustment of the friction force without the need to dismantle the damper
- Retrofitting on any existing stay cable (strand or parallel wire) on structures where unexpected cable vibrations have been observed
- All components can be replaced on site
- Damping characteristics independent of temperature variations or vibration frequencies

number of movable parts, which reduces the wear and tear. This approach makes VSL Dampers significantly more robust than other damping systems.

The VSL Friction damper is a highly efficient and durable damper for more critical applications, such as long cables or structures with an increased risk of vibration.

VSL VE damper - Tailor-made efficiency for short and medium stay cables

High-damping rubber: The VSL VE damper is composed of several special rubber pads and the cable's dynamic energy is dissipated by shear deformation. The damper pads are made of a high-damping rubber.

Great simplicity: The damper is modular, with the number of pads required depending on the dynamic characteristics of the cable. The simple and versatile system can be easily adapted to any cable size whether as a new installation or as part of a retrofitting solution.

Excellent durability: The high-damping rubber pads have a long design life and a high fatigue resistance. They require only minimal maintenance, which allows dampers to be installed even at the pylon where maintenance access is difficult to provide.

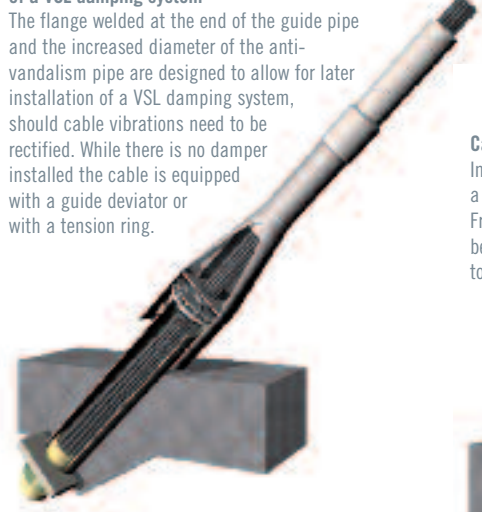
Tailor-made performance: The damper performance depends purely on the damping characteristics of the rubber pads and can be adjusted by varying the number and type of pads used. The damper performs at its best on short to medium length cables. Its performance can be further enhanced by increasing the distance between the damper and anchorage or by installing a second damper at the pylon. Its performance is independent of the vibration mode and is not particularly sensitive to temperature variations and frequency.

Compact aesthetics: The VE damper can be fully integrated into the SSI 2000 anti-vandalism pipe with minimum impact on the cable aesthetics. Solutions for retrofitting include simple neoprene boots or compact mounting frames in the case of external dampers.

The VSL VE damper is a simple and robust damper optimised for short to medium length stay cables with moderate damping requirements and for extradosed cables. Both dampers are incorporated into the SSI 2000 System as internal dampers, fully protected inside the anti-vandalism pipe. The dampers can either be installed together with the cable or retrofitted.

Connection detail for subsequent installation of a VSL damping system

The flange welded at the end of the guide pipe and the increased diameter of the anti-vandalism pipe are designed to allow for later installation of a VSL damping system, should cable vibrations need to be rectified. While there is no damper installed the cable is equipped with a guide deviator or with a tension ring.



Cable equipped with the VSL Friction damper

In the event of unexpected cable vibrations, a choice of VSL damping systems - Friction damper or VE damper - can be installed without modification to the cable assembly.



Provision of stabilising cross-ties

While VSL recommends the use of dampers for efficient vibration control, the SSI 2000 System allows also for installation of cross-ties if requested. Cross-ties help to increase the critical wind speed for aeroelastic instability by increasing the natural frequency of the cable. They are however only efficient in the cable plane and their installation and maintenance can constitute a significant additional cost.




VSL VE damper

Tried and tested

VSL Dampers have demonstrated their outstanding performance in a series of comparative tests on full-scale samples conducted by organisations such as Shanghai's Tongji University, Hong Kong Highways Department and the Korea Expressway Corporation, as well as on site.

Low maintenance has been confirmed for dampers installed since the mid 1990's.

STRAND-BY-STRAND METHOD FOR INSTALLATION OR REPLACEMENT OF CABLES



The strand-by-strand installation methods developed by VSL offer maximum flexibility and can be adapted to specific needs.

All SSI 2000 cables are installed strand-by-strand using extremely compact equipment and can be inspected and replaced if necessary in the same manner.

An optimised solution to streamline complex bridge erection cycles

The equipment can be handled manually at the anchorage location inside or outside the pylons, whatever their shapes. The strand reels are light and compact compared with prefabricated cables and can be easily lifted, transported and handled. This renders the cable installation largely independent of the logistics of deck and pylon construction. As a significant part of the installation can be carried out off the critical path, tower crane usage is reduced, resulting in cost and programme savings.

The preferred option for cable inspection or replacement under traffic

The compact equipment allows for inspection and replacement of the entire stay cable with minimum impact on the bridge traffic, as a single lane closure is typically sufficient to provide a safe working space. In addition, the strand-by-strand replacement makes the loss of cable force during the works negligible, allowing unrestricted vehicle movements.



Replacement of a 300m cable

In May 2002, VSL replaced a 298m-long cable on the Ching Chau Min Jiang Bridge, which had been damaged when a barge crane collided with the bridge during a typhoon. Site conditions did not allow access for a mobile crane and so all the equipment had to be handled manually. The cable was replaced strand by strand with VSL's lightweight equipment. This operation demonstrated that even long cables can be replaced with minimum disruption to bridge operations.

ALLATION

The main advantages of the VSL strand-by-strand system installation

- Absolute flexibility to adjust the cable length during construction to address variations in the bridge geometry or late changes to the deck erection methodology
- No requirement for provision of off-site prefabrication facilities
- No significant additional construction loads on the partially-completed structure as light and compact equipment is used.
- Fast erection cycle with partial and staged installation of cables for light composite deck assembly
- No additional requirement on the project's critical path for the use of tower and deck cranes during cable erection, thus reducing the risk of delay
- Lightweight shop prefabricated anchorages can be pre-installed during deck and pylon construction
- Easy second stage stressing with monostrand jacks, providing greater flexibility to designers and contractors by avoiding the relocation of heavy stressing and access equipment
- Improved site safety due to reduced component weights and simplified access arrangements
- Full strand-by-strand replacement
- Fully compatible with the VSL Saddle

A matching saddle

The SSI Saddle has been specifically designed to allow application of the same strand-by-strand principles for installation, inspection and replacement of the stay cables. All strands are individually encapsulated and guided within the saddle assembly, which combines the advantages of a saddle solution with the benefits of a strand system.



VSL lifting winch



VSL Automatic Monostrand Stressing (AMS) system

The AMS system provides fully-automatic control and recording of the stressing operation and management of all relevant stressing data. The system allows absolute flexibility in defining the stressing parameters to achieve either a required cable force or cable elongation

Specialist equipment and procedures

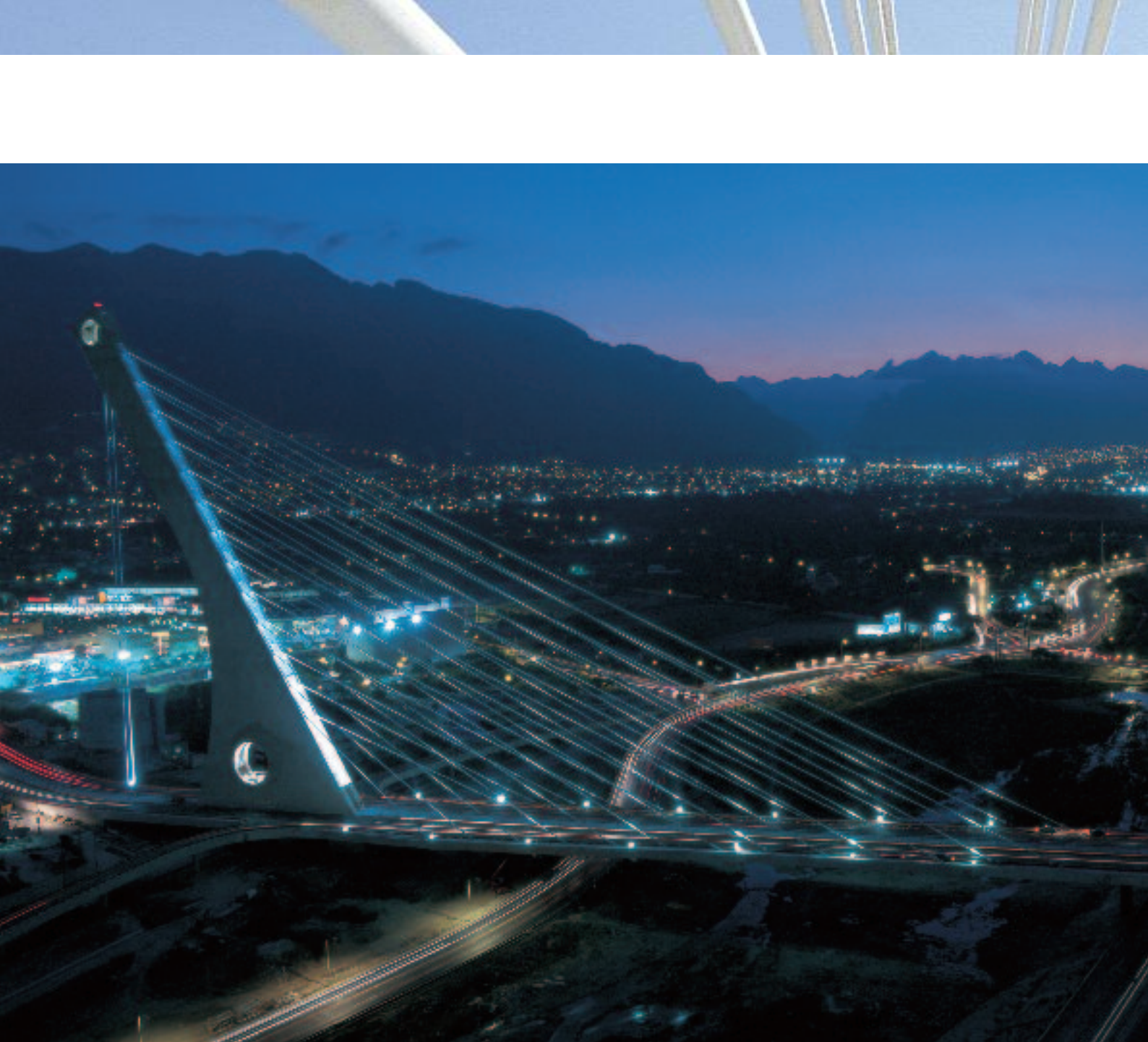
The continuous stay pipe is welded on site from elements of standard length. The strands are delivered to site in compact coils and are installed one by one using a small winch system. They are individually stressed by a lightweight monostrand jack from either the deck or the pylon end. The VSL AMS system provides fully automatic control, recording and data management for the stressing operation on site. Specialist procedures are implemented to ensure an equal final force in all strands and safe anchoring of low cable forces at intermediate stressing stages. The system provides absolute freedom to engineers to specify stressing either to a cable force or cable length, depending on the characteristics of the structure. It is even possible to change the cable length during construction if required. Final tuning of the completed cables can be carried out either by monostrand jack or by compact multistrand jacks. A ring nut is provided on the stressing anchorage to allow a reduction in the cable force if necessary without re-gripping the strand.



Flexible erection cycles

Lightweight equipment with independence from heavy craneage allows simultaneous working and a reduced number of activities on the critical path. The cable installation activities can be easily adapted to match the requirements of the deck construction cycle.





Puente La Unidad Bridge, Mexico (2003)

In a 50/50 JV, VSL provided project management, complete technical and method support and part of the production management. VSL Mexico also supplied and installed the post-tensioning, and the SSI 2000 Stay cable system



Badajoz Bridge, Spain (1994)
Cables equipped with friction dampers



Ponte Europa Bridge, Portugal (2002)
186m main span length - 91 strand cables



Batam Tonton Bridge, Indonesia (1997)
Design, supply and installation of stay cables, deck form-travellers and pylon formwork.
Construction engineering for the superstructure construction



Lazarevsky bridge, Saint Petersburg, Russia (2008)
Stays ranging from 6-55 to 6-73



Taipei Ring road Bridge, Taiwan (2009)
13 pairs of stays on each side of the pylon



Papendorpse Bridge, Netherlands (2002)
120 strand cables

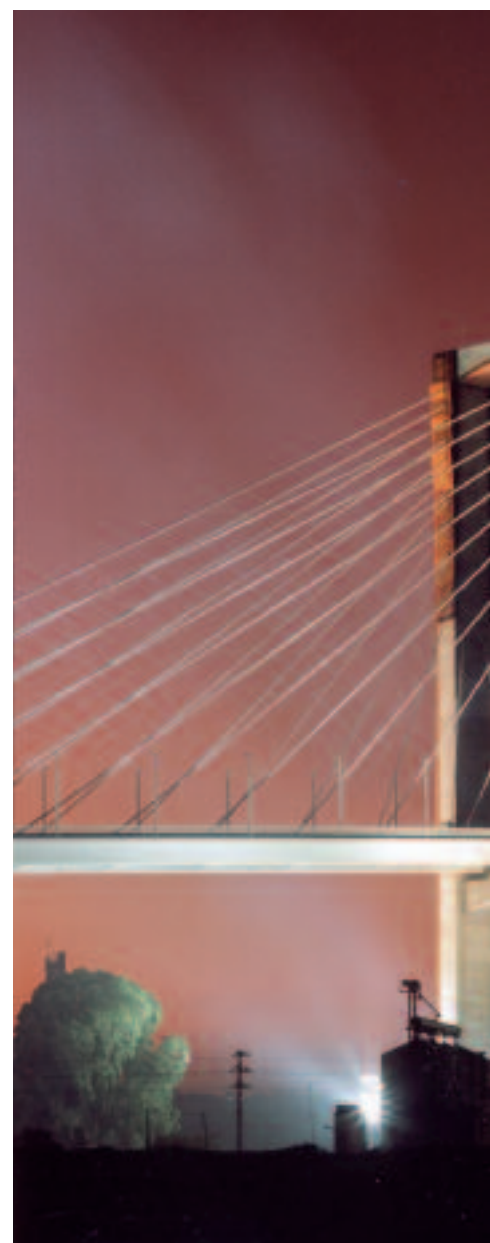


Sungai Johor Bridge, Malaysia (2008)
85 strand cables with lengths of up to 275m



Sucharskiego Bridge, Poland (2001)
Supply and installation of stay cables,
with VSL Friction dampers

Centenario Bridge, Spain (1991)
552m bridge length, with 264m for the main span





Wadi Abdoun Bridge, Jordan (2006)
Curved deck with inclined pylon



Yichong Yiling Bridge, China (2001)
Supply of stay cable system, erection equipment, stay cable engineering, site management and site supervision





Neva 1 Bridge, Russia (2002)
All cables equipped with VSL Friction dampers



Koshiki Daimyojin Bridge, Japan (1993)
Technical consultation and supply of the prefabricated stay cables

Fred Hartmann Bridge, USA (1995)
Supply of stay cables and supervision at installation





Sunshine Skyway Bridge, USA (1986)
Supply of post-tensioning and stay cables. Cables anchored to the pylon by saddles and equipped with hydraulic dampers



Neva 2 Bridge, Russia (2007)
Supply and installation of stay cables with VSL Friction dampers

Merida Arch Bridge, Spain (1991)
Supply and installation of the stay cables





Zizkova Footbridge, Czech Republic (2007)
Installation of stays and post-tensioning



© Jose Cartellone Construct

Pastaza Bridge, Ecuador (2005)
Supply and installation of the stay cables



Radès-la-Goulette Bridge, Tunisia (2007)
Extensive equipment and services



Keppel Bay Bridge, Singapore (2006)
Supply and operation of casting cells, erection of bridge deck, pylon construction, supply and installation of stay cables



Kien Hai Phong Bridge, Vietnam (2003)
Supply and installation of bearings and stay cables



Woonam Bridge, South Korea (2008)
VSL Saddle designed to allow cable replacement



Peldar Bridge, Columbia (2002)
VSL Saddle and monitoring services



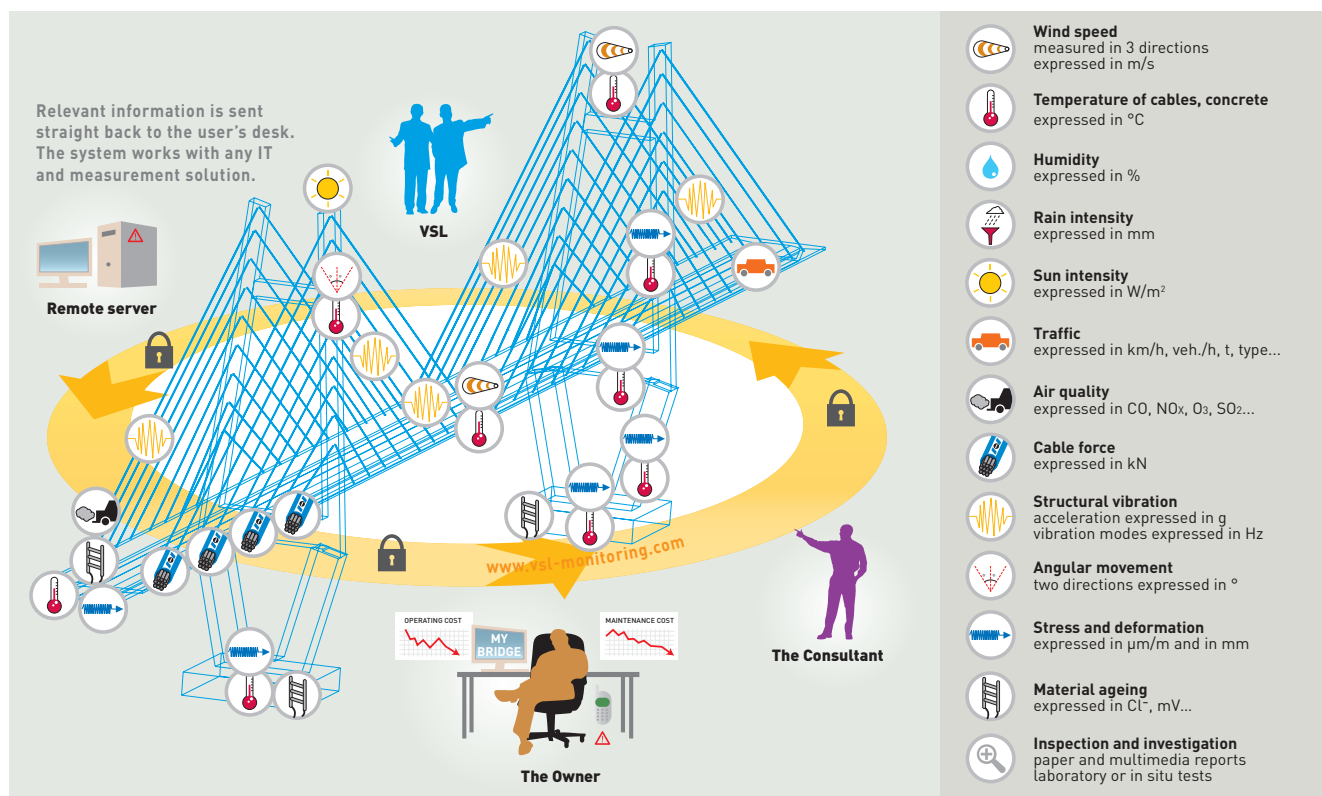
Safti Bridge, Singapore (1995)
An inclined pylon is stabilised by back-stay cables



Liz Bridge, Portugal (2004)
18 stay cables installed in one week

VSL SERVICES FOR STAY CABLE BRIDGES

MONITORING



DeMon system allows wireless connection from the client's office to any type of sensors on site through internet and wireless devices.

LAUNCHING GANTRIES



Shenzhen Western Corridor - Hong Kong

HEAVY LIFTING



Stonecutters Bridge - Hong Kong

DAMPERS



VSL Dampers

E CONSTRUCTION

FORM TRAVELLERS & LIFTING FRAMES



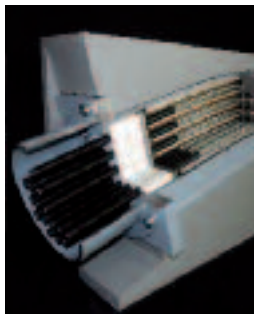
West Tsing Yi - Hong Kong

REPAIR



Figueira Da Foz Bridge repair - Portugal

SADDLE



VSL SSI Saddle for a compact and slender pylon design

BEARINGS & JOINTS



Pot bearing



Preloaded seismic bearing

GROUND ENGINEERING



Ground anchors



VSOL® walls



D-walls & Piles



Ground improvement



Ground investigation

CONSTRUCTION



Bridges



Buildings



Slab on grade



Nuclear Containments



Offshore structures



LNG & LPG containments

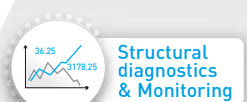


Heavy lifting



Formwork & Equipment

REPAIR, STRENGTHENING & PRESERVATION



Structural diagnostics & Monitoring



Repair & Strengthening



Infrastructure Preservation



Infrastructure Protection

SYSTEMS & TECHNOLOGIES

- Post-tensioning strand systems
- Bars & post-tensioning bar systems
- Stay cable systems
- Damping systems (stays & buildings)
- Ductal® ultra-high performance concrete
- Bearings & Joints

www.vsl.com

VSL LOCATIONS



Headquarters

VSL International Ltd.
Sägestrasse 76
CH-3098 Köniz
Switzerland
Phone: +41 58 456 30 00
info@vsl.com

Americas /

ARGENTINA

VSL Sistemas Especiales de
Construcción Argentina SA
BUENOS AIRES
Phone: +54 11 5272 87 52

BOLIVIA

Postensados de Bolivia
SAN MIGUEL, LA PAZ
Phone: +591 2 27 70 338

BRAZIL

VSL Brasil Construção e
Recuperação Ltda
SÃO PAULO
Phone: +55 113 521 7153/4

CANADA

CTT Stronghold Canada
TORONTO
Phone: +1 416 477 1042

CHILE

VSL Sistemas Especiales de
Construcción S.A.
SANTIAGO
Phone: +56 2 2571 6700

COLOMBIA

Sistemas Especiales de
Construcción S.A.S
BOGOTÁ
Phone: +57 1 226 6230

MEXICO

VSL Corporation Mexico S.A de C.V
MEXICO
Phone: +52 55 55 11 20 36

PERU

Sistemas Especiales de Construcción
Peru S.A.
LIMA
Phone: +51 1 349 38 38

VSL Peru S.A.C

LIMA
Phone: +51 1 713 98 32

UNITED STATES OF AMERICA

VStructural LLC
BALTIMORE, MD
Phone: +1 410 850 7000

Africa /

EGYPT

VSL Egypt
CAIRO
Phone: +20 2 344 19 00

SOUTH AFRICA

VSL Construction Solutions (Pty) Ltd
JOHANNESBURG
Phone: +010 492 1811

TUNISIA

VSL Tunisia
TUNIS
Phone: +216 70 72 84 73

Europe /

AUSTRIA

Grund-Pfahl- und Sonderbau
GmbH
HIMBERG
Phone: +43 2235 87 777

CZECH REPUBLIC

VSL Systémy / CZ / s.r.o.
PRAGUE
Phone: +420 2 51 09 16 80

FRANCE

VSL France S.A. (Bouygues TPRF)
LABÈGE
Phone: +33 5 33 65 96 59

GERMANY

VSL Systems GmbH
BERLIN
Phone: +41 58 456 30 30

NETHERLANDS

Heijmans Civiel b.v.
Span en Verplaatsingstechnieken
ROSMALLEN
Phone: +31 73 543 6611

NORWAY

Spennarmering Norge AS
RUD
Phone: +47 98 21 02 31

POLAND

VSL Polska Sp. Zo. o
WARSZAWA
Phone: +48 22849 22 09

PORTUGAL

VSL Sistemas Portugal SA
PAÇO DE ARCOS
Phone: +351 21 445 83 10

Delegação Norte
VILA NOVA DE GAIA
Phone: +351 22 371 18 80

SPAIN

VSL Construction Systems SA
BARCELONA
Phone: +34 93 289 23 30

SWEDEN

Internordisk Spännarmering AB
VÄSTERHANINGE
Phone: +46 10 448 11 42

SWITZERLAND

VSL (Switzerland) Ltd.
SUBINGEN
Phone: +41 58 456 30 30

SAINT LEGIER

Phone: +41 58 456 30 00

TURKEY

Mega Yapi Construction &
Trade Co. Ltd
ANKARA
Phone: +90 312 490 90 66

UNITED KINGDOM

VSL System (UK) Ltd.
LUTON
Phone: +44 148 040 4401

VSL Infrastructure Protection Ltd.

LONDON
Phone: +44 207 803 3614
SINGAPORE
Phone: +65 65 59 12 22
SYDNEY
Phone: +61 2 94 84 5944

Middle East /

SULTANATE OF OMAN

VSL Muscat LLC
MUSCAT
Phone: +971 4 885 7225

UNITED ARAB EMIRATES

VSL Middle East LLC
DUBAI, UAE
Phone: +971 4 885 0004

DOHA, QATAR

Phone: +974 44 052 444

Asia /

BRUNEI

VSL Systems (B) Sdn. Bhd.
BRUNEI DARUSSALAM
Phone: +673 2 380 153 / 381 827

CHINA PRC

VSL Engineering Corp., Ltd.
(China)

HEFEI

Phone: +86 551 382 29 18

HONG KONG

VSL Hong Kong Ltd.
CHAI WAN
Phone: +852 2590 22 88

INDIA

VSL India Private Ltd.
CHENNAI
Phone: +91 44 4225 11 11

INDONESIA

PT VSL Indonesia
JAKARTA
Phone: +62 21 570 07 86

JAPAN

VSL Japan Corporation
TOKYO
Phone: +81 3 3346 8913

KOREA

VSL Korea Co. Ltd.
SEOUL
Phone: +82 2 553 8200

MALAYSIA

VSL Engineers (M) Sdn. Bhd.
KUALA LUMPUR
Phone: +603 7981 47 42

PHILIPPINES

VSL Philippines Inc.
MANDALUYONG CITY
Phone: +632 722 1703

SINGAPORE

VSL Singapore Pte. Ltd.
SINGAPORE
Phone: +65 6559 12 22

TAIWAN

VSL Taiwan Ltd.
TAIPEI
Phone: +886 2 2759 6819

THAILAND

VSL (Thailand) Co. Ltd.
BANGKOK
Phone: +66 2 679 76 15 - 19

VIETNAM

VSL Vietnam Ltd.
HANOI
Phone: +84 4 3976 5088
HO CHI MINH CITY
Phone: +84 8 810 6817

Australia /

VSL Australia Pty. Ltd.
NEW SOUTH WALES
Phone: +61 2 9484 5944

QUEENSLAND

Phone: +61 7 3327 0200

VICTORIA

Phone: +61 3 979 503 66

SOUTH AUSTRALIA

Phone: +61 8 8252 1900

TASMANIA

Phone: +61 3 6249 3044

PERTH

Phone: +61 8 9419 1119

FT Laboratories Ltd.

PING CHE, HONG KONG
Phone: +852 2758 48 61

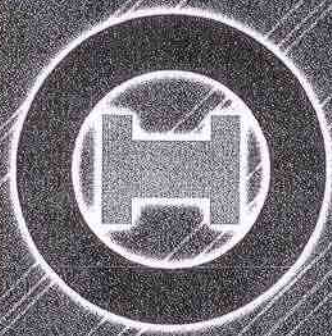
VSL Offshore Pte Ltd.

SINGAPORE
Phone: +65 65 59 13 05

Copyright 12/2013, VSL International Ltd.
Printed in France – patented.

The information set forth in this brochure including technical and engineering data is presented for general information only. While every effort has been made to insure its accuracy, this information should not be used or relied upon for any specific application without independent professional examination and verification of its accuracy, suitability and applicability. Anyone using this material assumes any and all liability resulting from such use. VSL disclaims any and all express or implied warranties of merchantability fitness for any general or particular purpose or freedom from infringement of any patent, trademark, or copyright in regard to the information or products contained or referred to herein. Nothing herein contained shall be construed as granting a license, express or implied under any patents.

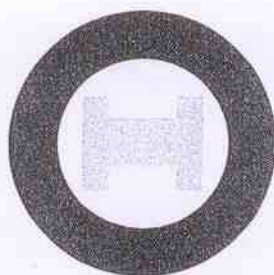




PT CIGADING HAKEAM CENTRE

H-BEAM SPECIFICATIONS





PT CIGADING HABEAM CENTRE

JAKARTA OFFICE

Caputra Building

Jl. K.H. Hasyim Ashari No. 2

Jakarta - 10130

Phone : 62-21-6345106 (5 Lines), 6343405, 6343906, 6326323,

6326324, 6343933, 6345560, 6347827

Fax : 62-21-6338438

E-mail : marketing@cigading-habeam.com

www.cigading-habeam.com

FACTORY

KRAKATAU INDUSTRIAL ESTATE

Phone : 62-254-371271, 385434

Fax : 62-254-392436



Certificate Number Q 14601



H - BEAM SPECIFICATIONS
PT. CIGADING HABEAM CENTRE

DAFTAR ISI CONTENTS

SIFAT-SIFAT MEKANIS <i>MECHANICAL PROPERTIES</i>	4
BATAS MINIMUM UKURAN PENGELASAN <i>SIZE LIMITATIONS FOR FILLET WELDS</i>	4
BENTUK DAN TOLERANSI PADA DIMENSI BAJA - H <i>SHAPE AND TOLERANCE ON DIMENSION OF H - STEEL</i>	5
DAFTAR UKURAN BAJA <i>LIST OF H - BEAM SIZES</i>	6
UKURAN DAN SIFAT-SIFAT PENAMPANG <i>SIZE AND SECTION PROPERTIES</i>	7



SIFAT - SIFAT MEKANIS / MECHANICAL PROPERTIES

MECHANICAL PROPERTIES

JIS	Yield Strength (kgf/mm ²)			Tensile Strength (kgf/mm ²)
	t < 16 mm	16 < t < 40 mm	t > 40 mm	
G3101 SS400	25 min	24 min	22 min	41-52
G3106 SM490A	3 min	32 min	30 min	50-62

PRODUCT SPECIFICATIONS Steel Grade

JIS	Chemical Composition				
	C	Mn	P	S	Si
G3101 SS400	-	-	0,05% max	0,05 % max	-
G 3106 SM490A	0,20 % max (t= 50 mm (0,22 % max (50<t≤100 mm	1,50 % max	0,04 % max	0,04 % max	0,55 % max

BATAS MINIMUM UKURAN PENGELASAN / SIZE LIMITATION FOR WELDS

Minimum Size Fillet Weld and Minimum Effective Throat for Partial Joint Penetration Groove Welds
(from AISC-Table 1.17.2 and AWS D1.1 (1996) Tables 5.8 and 3.4)

Base Metal Thickness (T) Of Thicker Part Joined (mm)	Minimum Size* Of Fillet Weld (mm)	Minimum Effective Throat (te) For Partial Joint Penetration Groove Weld (mm)
T ≤ 6.4	3	3
6.4 < T ≤ 12.7	5	5
12.7 < T ≤ 19.0	6	6
19.0 < T ≤ 38.1	8	8
38.1 < T ≤ 57.1	8	10
57.1 < T ≤ 152	8	13
152 < T	8	16

* Weld size is the leg dimension of fillet weld.

The weld size need not exceed the thickness of the thinner part joined.

For this exception particular care should be taken provide sufficient preheat to ensure weld soundness.

- Minimum size for bridge applications is 5 mm
- Minimum single pass welds must be used



BENTUK DAN TOLERANSI PADA DIMENSI BAJA - H / SHAPE AND TOLERANCE ON DIMENSION OF H - STEEL

Shape and dimensional tolerance of H sections JIS G 3192

Unit in mm

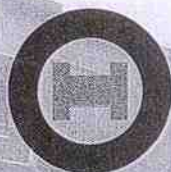
Dimension		Tolerance	Remarks
Width (B)	Under 100 in nominal width	± 2.0	
	100 or over to and excl. 200 in nominal width	± 2.5	
	200 or over in nominal width	± 3.0	
Depth (H)	Under 400 in nominal depth	± 2.0	
	400 or over to and excl. 600 in nominal depth	± 3.0	
	600 or over in nominal depth	± 4.0	
Thickness	Flange (t2)	Under 16	
		16 or over to and excl. 25	
		25 or over to and excl. 40	
		40 or over	
	Web (tr)	Under 16	
		16 or over to and excl. 25	
		25 or over to and excl. 40	
		40 or over	
Length	7 m or under	+40 0	
	Over 7 m	Add 5 mm to the Plus side tolerance Given in the above Column for every 1 m Increase in length Or its fraction.	
Out-of-square (T)	300 or under in nominal depth	1.0 % or under of width B, provided that 1.5 mm is the minimum.	
	Over 300 in nominal depth	1.2 % or under of width B, provided that 1.5 mm is the minimum.	
Bend	300 or under in nominal depth	0.15 % or under of length	To be applied to bend such as sweep and camber
	Over 300 in nominal depth	0.10 % or under of length	
Web-off -center (S)	300 or under in nominal depth and 200 or under in nominal width	± 2.5	$S = \frac{b_1 - b_2}{2}$
	Over 300 in nominal depth and over 200 in nominal width	± 3.5	
Concavity of web (W)	Under 400 in nominal depth	2.0	
	400 or over to and excl. 600	2.5	
	600 or over	3.0	
Ends-out-of-square (e)		16 % or under of width B or of depth H, provided that 3.0 mm is the minimum.	



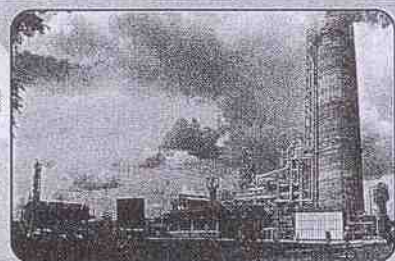
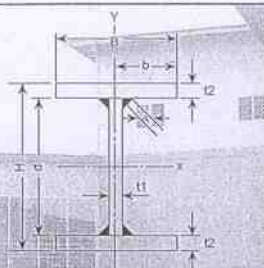
PT CIGADING HABEAM CENTRE

DAFTAR UKURAN BAJA / LIST OF H-BEAM SIZES

HxB	Halaman	HxB	Halaman	HxB	Halaman	HxB	Halaman
200x100	7	500x225	16	850x300	33	1.200x250	52
200x125		500x250		850x350		1.200x300	
200x150		500x275		850x400	34	1.200x350	53
200x175		500x300	17	850x450		1.200x400	
200x200		500x325		900x200	35	1.200x450	
250x100		500x350	18	900x250			
250x125		500x375		900x300	36		
250x150		500x400		900x350			
250x175		500x425	19	900x400	37		
250x200		500x450		900x450			
250x250		500x475		950x200	38		
300x150	8	500x500	20	950x250			
300x175		550x200		950x300	39		
300x200		550x250		950x350			
300x225		550x300	21	950x400	40		
300x250		550x350		950x450			
300x275		550x400			41		
300x300		600x200	22	1.000x200			
350x150	9	600x250		1.000x250	42		
350x175		600x300		1.000x300			
350x200		600x350	23	1.000x350			
350x225		600x400		1.000x400	43		
350x250		650x200		1.000x450			
350x275		650x250	24	1.050x200	44		
350x300	10	650x300		1.050x250			
350x325		650x350	25	1.050x300	45		
350x350		650x400		1.050x350			
400x200		700x200		1.050x400	46		
400x225		700x250	26	1.050x450			
400x250		700x300		1.100x200	47		
400x275	11	700x350		1.100x250			
400x300		700x400	27	1.100x300			
400x325		750x200		1.100x350	48		
400x350		750x250	28	1.100x400			
400x375		750x300		1.100x450	49		
400x400		750x350		1.150x200			
450x200	13	750x400	29	1.150x250	50		
450x225		800x200		1.150x300			
450x250		800x250	30	1.150x350			
450x275		800x300		1.150x400	51		
450x300		800x350		1.150x450			
450x325		800x400	31	1.200x200			
450x350	14	800x450					
450x375		850x200	32				
450x400		850x250					
450x425							
450x450							
500x200	15						



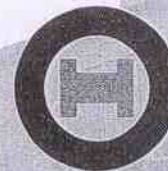
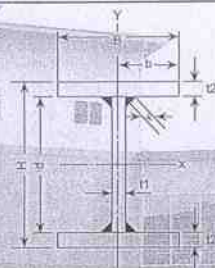
PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
200	100	5.5	8.0	5.0	26.62	20.9	1760.932	133.588	8.1	2.24	176.093	26.7*)
200	100	6.0	9.0	5.0	29.42	23.1	1944.288	150.328	8.1	2.26	194.429	30.1
200	100	7.0	11.0	5.0	34.96	27.4	2295.859	183.842	8.1	2.29	229.586	36.8
200	100	8.0	12.0	5.6	38.71	30.4	2486.972	200.751	8.0	2.28	248.697	40.2
200	125	5.5	8.0	5.0	30.62	24.0	2129.786	260.672	8.3	2.92	212.979	41.7
200	125	6.0	9.0	5.0	33.92	26.6	2355.003	293.296	8.3	2.94	235.50	46.9
200	125	7.0	11.0	5.0	40.46	31.8	2787.577	358.582	8.3	2.98	278.758	57.4
200	125	8.0	12.0	5.6	44.71	35.1	3017.852	391.376	8.2	2.96	301.785	62.6
200	150	5.5	8.0	5.0	34.62	27.2	2498.639	450.255	8.5	3.61	249.864	60.0
200	150	6.0	9.0	5.0	38.42	30.2	2765.718	506.578	8.5	3.63	276.572	67.5
200	150	7.0	11.0	5.0	45.96	36.1	3279.296	619.259	8.4	3.67	327.930	82.6
200	150	8.0	12.0	5.6	50.71	39.8	3548.732	675.751	8.4	3.65	354.873	90.1
200	175	5.5	8.0	5.0	38.62	30.3	2867.492	714.838	8.6	4.30	286.749	81.7
200	175	6.0	9.0	5.0	42.92	33.7	3176.433	804.234	8.6	4.33	317.643	91.9
200	175	7.0	11.0	5.0	51.46	40.4	3771.014	983.061	8.6	4.37	377.101	112.3
200	175	8.0	12.0	5.6	56.71	44.5	4079.612	1072.626	8.5	4.35	407.961	122.6
200	200	5.5	8.0	5.0	42.62	33.5	3236.346	1066.922	8.7	5.00	323.635	106.7
200	200	6.0	9.0	5.0	47.42	37.2	3587.148	1200.328	8.7	5.03	358.715	120.0
200	200	7.0	11.0	5.0	56.96	44.7	4262.732	1467.175	8.7	5.08	426.273	146.7
200	200	8.0	12.0	5.6	62.71	49.2	4610.492	1600.751	8.6	5.05	461.049	160.1
250	100	5.5	8.0	5.0	29.37	23.1	2930.671	133.658	10.0	2.13	234.454	26.7
250	100	6.0	9.0	5.0	32.42	25.4	3239.218	150.418	10.0	2.15	259.137	30.1
250	100	7.0	11.0	5.0	38.46	30.2	3835.261	183.985	10.0	2.19	306.821	36.8
250	100	8.0	12.0	5.6	42.71	33.5	4171.065	200.964	9.9	2.17	333.685	40.2
250	125	5.5	8.0	5.0	33.37	26.2	3516.525	260.741	10.3	2.80	281.322	41.7
250	125	6.0	9.0	5.0	36.92	29.0	3892.933	293.386	10.3	2.82	311.435	46.9
250	125	7.0	11.0	5.0	43.96	34.5	4621.229	358.725	10.3	2.86	369.698	57.4
250	125	8.0	12.0	5.6	48.71	38.2	5021.445	391.589	10.2	2.84	401.716	62.7
250	150	5.5	8.0	5.0	37.37	29.3	4102.378	450.324	10.5	3.47	328.190	60.0
250	150	6.0	9.0	5.0	41.42	32.5	4546.648	506.668	10.5	3.50	363.732	67.6
250	150	7.0	11.0	5.0	49.46	38.8	5407.197	619.402	10.5	3.54	432.576	82.6
250	150	8.0	12.0	5.6	54.71	42.9	5871.825	675.964	10.4	3.52	469.746	90.1

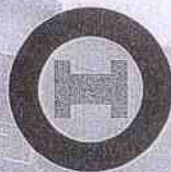
Catatan : *) Mulai Juli 2000 telah kami produksi



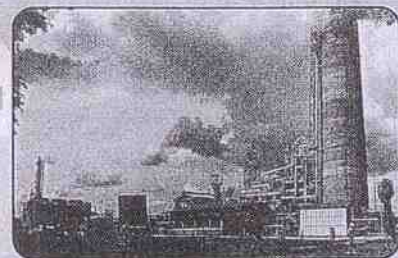
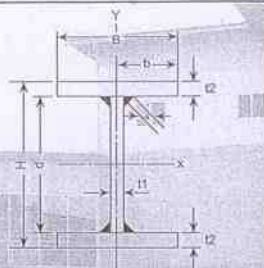
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
250	175	5.5.0	8.0.0	5.0	41.37	32.5	4688.231	714.908	10.6	4.16	375.059	81.7
250	175	6.0.0	9.0.0	5.0	45.92	36.0	5200.363	804.324	10.6	4.19	416.029	91.9
250	175	7.0.0	11.0.0	5.0	54.96	43.1	6193.166	983.204	10.6	4.23	495.453	112.4
250	175	8.0.0	12.0.0	5.6	60.71	47.7	6722.205	1072.839	10.5	4.20	537.776	122.6
250	200	5.5.0	8.0.0	5.0	45.37	35.6	5274.085	1066.991	10.8	4.85	421.927	106.7
250	200	6.0.0	9.0.0	5.0	50.42	39.6	5854.078	1200.418	10.8	4.88	468.326	120.0
250	200	7.0.0	11.0.0	5.0	60.46	47.5	6979.134	1467.318	10.7	4.93	558.331	146.7
250	200	8.0.0	12.0.0	5.6	66.71	52.4	7572.585	1600.964	10.7	4.90	605.807	160.1
250	250	5.5.0	8.0.0	5.0	53.37	41.9	6445.791	2083.658	11.0	6.25	515.663	166.7
250	250	6.0.0	9.0.0	5.0	59.42	46.6	7161.508	2344.168	11.0	6.28	572.921	187.5
250	250	7.0.0	11.0.0	5.0	71.46	56.1	8551.071	2865.235	10.9	6.33	684.086	229.2
250	250	8.0.0	12.0.0	5.6	78.71	61.8	9273.345	3125.964	10.9	6.30	741.868	250.1
300	150	6.0.0	9.0.0	5.0	44.42	34.9	6839.078	506.758	12.4	3.38	455.939	67.6
300	150	6.0.0	12.0.0	5.0	53.06	41.7	8520.509	675.497	12.7	3.57	568.034	90.1
300	150	9.0.0	12.0.0	6.3	61.63	48.4	9046.123	676.677	12.1	3.31	603.075	90.2
300	150	9.0.0	16.0.0	6.3	72.91	57.2	11132.622	901.628	12.4	3.52	742.175	120.2
300	175	6.0.0	9.0.0	5.0	48.92	38.4	7792.043	804.414	12.6	4.06	519.470	91.9
300	175	6.0.0	12.0.0	5.0	59.06	46.4	9765.389	1072.372	12.9	4.26	651.026	122.6
300	175	9.0.0	12.0.0	6.3	67.63	53.1	10291.003	1073.552	12.3	3.98	686.067	122.7
300	175	9.0.0	16.0.0	6.3	80.91	63.5	12747.449	1430.795	12.6	4.21	849.830	163.5
300	200	6.0.0	9.0.0	5.0	53.42	41.9	8745.008	1200.508	12.8	4.74	583.001	120.1
300	200	6.0.0	12.0.0	5.0	65.06	51.1	11010.269	1600.497	13.0	4.96	734.018	160.0
300	200	9.0.0	12.0.0	6.3	73.63	57.8	11535.883	1601.677	12.5	4.66	769.059	160.2
300	200	9.0.0	16.0.0	6.3	88.91	69.8	14362.276	2134.961	12.7	4.90	957.485	213.5
300	225	6.0.0	9.0.0	5.0	57.92	45.5	9697.973	1709.101	12.9	5.43	646.532	151.9
300	225	6.0.0	12.0.0	5.0	71.06	55.8	12255.149	2278.622	13.1	5.66	817.010	202.5
300	225	9.0.0	12.0.0	6.3	79.63	62.5	12780.763	2279.802	12.7	5.35	852.051	202.6
300	225	9.0.0	16.0.0	6.3	96.91	76.1	15977.102	3039.128	12.8	5.60	1065.140	270.1
300	250	6.0.0	9.0.0	5.0	62.42	49.0	10650.938	2344.258	13.1	6.13	710.063	187.5
300	250	6.0.0	12.0.0	5.0	77.06	60.5	13500.029	3125.497	13.2	6.37	900.002	250.0
300	250	9.0.0	12.0.0	6.3	85.63	67.2	14025.643	3126.677	12.8	6.04	935.043	250.1
300	250	9.0.0	14.0.0	6.3	95.27	74.8	15835.007	3647.486	12.9	6.19	1055.667	291.8
300	250	9.0.0	16.0.0	6.3	104.91	82.4	17591.929	4168.295	12.9	6.30	1172.795	333.5

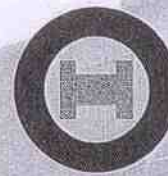
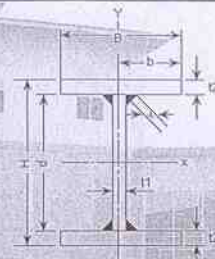


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

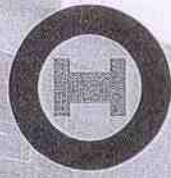
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
300	275	6.0.0	9.0.0	5.0	66.92	52.5	11603.903	3120.039	13.2	6.83	773.594	226.9
300	275	6.0.0	12.0.0	5.0	83.06	65.2	14744.909	4159.872	13.3	7.08	982.994	302.5
300	275	9.0.0	12.0.0	6.3	91.63	71.9	15270.523	4161.052	12.9	6.74	1018.035	302.6
300	275	9.0.0	14.0.0	6.3	102.27	80.3	17267.580	4854.257	13.0	6.89	1151.172	353.0
300	275	9.0.0	16.0.0	6.3	112.91	88.6	19206.756	5547.461	13.0	7.01	1280.450	403.5
300	300	6.0.0	9.0.0	5.0	71.42	56.1	12556.868	4050.508	13.3	7.53	837.125	270.0
300	300	6.0.0	12.0.0	5.0	89.06	69.9	15989.789	5400.497	13.4	7.79	1065.986	360.0
300	300	6.0.0	14.0.0	5.0	100.82	79.1	18197.062	6300.490	13.4	7.91	1213.137	420.0
300	300	9.0.0	12.0.0	6.3	97.63	76.6	16515.403	5401.677	13.0	7.44	1101.027	360.1
300	300	9.0.0	14.0.0	6.3	109.27	85.8	18700.154	6301.652	13.1	7.59	1246.677	420.1
300	300	9.0.0	16.0.0	6.3	120.91	94.9	20821.582	7201.628	13.1	7.72	1388.105	480.1
300	300	12.0.0	16.0.0	8.4	129.57	101.7	21302.803	7203.859	12.8	7.46	1420.187	480.3
300	300	12.0.0	19.0.0	8.4	146.85	115.3	24336.653	8553.773	12.9	7.63	1622.444	570.3
350	150	6.0.0	9.0.0	5.0	47.42	37.2	9680.508	506.848	14.3	3.27	553.172	67.6
350	150	6.0.0	12.0.0	5.0	56.06	44.0	12018.579	675.587	14.6	3.47	686.776	90.1
350	150	9.0.0	12.0.0	6.3	66.13	51.9	12884.728	676.980	14.0	3.20	736.270	90.3
350	150	9.0.0	16.0.0	6.3	77.41	60.8	15808.767	901.932	14.3	3.41	903.358	120.3
350	175	6.0.0	9.0.0	5.0	51.92	40.8	10988.973	804.504	14.5	3.94	627.941	91.9
350	175	6.0.0	12.0.0	5.0	62.06	48.7	13732.959	1072.462	14.9	4.16	784.741	122.6
350	175	9.0.0	12.0.0	6.3	72.13	56.6	14599.108	1073.855	14.2	3.86	834.235	122.7
350	175	9.0.0	16.0.0	6.3	85.41	67.0	18041.594	1431.099	14.5	4.09	1030.948	163.6
350	200	6.0.0	9.0.0	5.0	56.42	44.3	12297.438	1200.598	14.8	4.61	702.711	120.1
350	200	6.0.0	12.0.0	5.0	68.06	53.4	15447.339	1600.587	15.1	4.85	882.705	160.1
350	200	9.0.0	12.0.0	6.3	78.13	61.3	16313.488	1601.980	14.4	4.53	932.199	160.2
350	200	9.0.0	16.0.0	6.3	93.41	73.3	20274.421	2135.265	14.7	4.78	1158.538	213.5
350	225	6.0.0	9.0.0	5.0	60.92	47.8	13605.903	1709.191	14.9	5.30	777.480	151.9
350	225	6.0.0	12.0.0	5.0	74.06	58.1	17161.719	2278.712	15.2	5.55	980.670	202.6
350	225	9.0.0	12.0.0	6.3	84.13	66.0	18027.868	2280.105	14.6	5.21	1030.164	202.7
350	225	9.0.0	16.0.0	6.3	101.41	79.6	22507.247	3039.432	14.9	5.47	1286.128	270.2
350	250	6.0.0	9.0.0	5.0	65.42	51.4	14914.368	2344.348	15.1	5.99	852.250	187.5
350	250	6.0.0	12.0.0	5.0	80.06	62.8	18876.099	3125.587	15.4	6.25	1078.634	250.0
350	250	9.0.0	12.0.0	6.3	90.13	70.8	19742.248	3126.980	14.8	5.89	1128.128	250.2
350	250	9.0.0	14.0.0	6.3	99.77	78.3	22272.202	3647.789	14.9	6.05	1272.697	291.8
350	250	9.0.0	16.0.0	6.3	109.41	85.9	24740.074	4168.599	15.0	6.17	1413.719	333.5



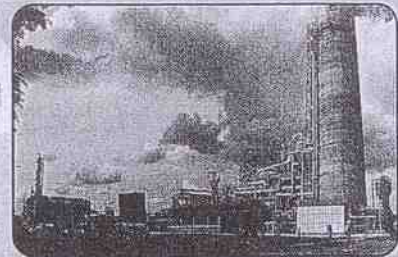
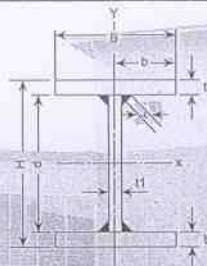
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
350	275	6.0.0	9.0.0	5.0	69.92	54.9	16222.833	3120.129	15.2	6.68	927.019	226.9
350	275	6.0.0	12.0.0	5.0	86.06	67.6	20590.479	4159.962	15.5	6.95	1176.599	302.5
350	275	9.0.0	12.0.0	6.3	96.13	75.5	21456.628	4161.355	14.9	6.58	1226.093	302.6
350	275	9.0.0	14.0.0	6.3	106.77	83.8	24249.025	4854.560	15.1	6.74	1385.659	353.1
350	275	9.0.0	16.0.0	6.3	117.41	92.2	26972.901	5547.765	15.2	6.87	1541.309	403.5
350	300	6.0.0	9.0.0	5.0	74.42	58.4	17531.298	4050.598	15.3	7.38	1001.788	270.0
350	300	6.0.0	12.0.0	5.0	92.06	72.3	22304.859	5400.587	15.6	7.66	1274.563	360.0
350	300	6.0.0	14.0.0	5.0	103.82	81.5	25391.192	6300.580	15.6	7.79	1450.925	420.0
350	300	9.0.0	12.0.0	6.3	102.13	80.2	23171.008	5401.980	15.1	7.27	1324.058	360.1
350	300	9.0.0	14.0.0	6.3	113.77	89.3	26225.849	6301.956	15.2	7.44	1498.620	420.1
350	300	9.0.0	16.0.0	6.3	125.41	98.4	29205.727	7201.932	15.3	7.58	1668.899	480.1
350	300	12.0.0	16.0.0	8.4	135.57	106.4	30009.663	7204.579	14.9	7.29	1714.838	480.3
350	300	12.0.0	19.0.0	8.4	152.85	120.0	34296.313	8554.493	15.0	7.48	1959.789	570.3
350	325	6.0.0	9.0.0	5.0	78.92	62.0	18839.763	5149.816	15.5	8.08	1076.558	316.9
350	325	6.0.0	12.0.0	5.0	98.06	77.0	24019.239	6866.212	15.7	8.37	1372.528	422.5
350	325	6.0.0	14.0.0	5.0	110.82	87.0	27368.016	8010.475	15.7	8.50	1563.887	493.0
350	325	9.0.0	12.0.0	6.3	108.13	84.9	24885.388	6867.605	15.2	7.97	1422.022	422.6
350	325	9.0.0	14.0.0	6.3	120.77	94.8	28202.672	8011.852	15.3	8.14	1611.581	493.0
350	325	9.0.0	16.0.0	6.3	133.41	104.7	31438.554	9156.099	15.4	8.28	1796.489	563.5
350	325	12.0.0	16.0.0	8.4	143.57	112.7	32242.490	9158.746	15.0	7.99	1842.428	563.6
350	325	12.0.0	19.0.0	8.4	162.35	127.4	36901.244	10875.066	15.1	8.18	2108.643	669.2
350	350	6.0.0	9.0.0	5.0	83.42	65.5	20148.228	6431.848	15.5	8.78	1151.327	367.5
350	350	6.0.0	12.0.0	5.0	104.06	81.7	25733.619	8575.587	15.7	9.08	1470.493	490.0
350	350	6.0.0	14.0.0	5.0	117.82	92.5	29344.839	10004.746	15.8	9.21	1676.848	571.7
350	350	9.0.0	12.0.0	6.3	114.13	89.6	26599.768	8576.980	15.3	8.67	1519.987	490.1
350	350	9.0.0	14.0.0	6.3	127.77	100.3	30179.495	10006.123	15.4	8.85	1724.543	571.8
350	350	9.0.0	16.0.0	6.3	141.41	111.0	33671.381	11435.265	15.4	8.99	1924.079	653.4
350	350	12.0.0	16.0.0	8.4	151.57	119.0	34475.317	11437.913	15.1	8.69	1970.018	653.6
350	350	12.0.0	19.0.0	8.4	171.85	134.9	39506.176	13581.576	15.2	8.89	2257.496	776.1
400	200	6.0.0	9.0.0	5.0	59.42	46.6	16548.868	1200.688	16.7	4.50	827.443	120.1
400	200	6.0.0	12.0.0	5.0	71.06	55.8	20728.909	1600.677	17.1	4.75	1036.445	160.1
400	200	9.0.0	12.0.0	6.3	82.63	64.9	22057.843	1602.284	16.3	4.40	1102.892	160.2
400	200	9.0.0	14.0.0	6.3	90.27	70.9	24729.50	1868.927	16.6	4.55	1236.475	186.9
400	200	9.0.0	16.0.0	6.3	97.91	76.9	27344.316	2135.569	16.7	4.67	1367.216	213.6
400	200	12.0.0	16.0.0	8.4	109.57	86.0	28590.217	2138.633	16.2	4.42	1429.511	213.9
400	200	12.0.0	19.0.0	8.4	120.85	94.9	32347.246	2538.546	16.4	4.58	1617.362	253.9

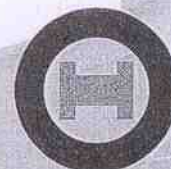
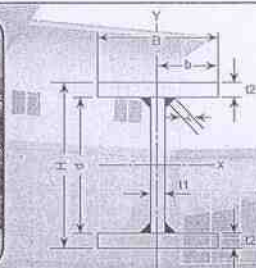


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

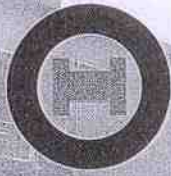
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
400	225	6.0.0	9.0.0	5.0	63.92	50.2	18269.083	1709.281	16.9	5.17	913.454	151.9
400	225	6.0.0	12.0.0	5.0	77.06	60.5	22987.789	2278.802	17.3	5.44	1149.389	202.6
400	225	9.0.0	12.0.0	6.3	88.63	69.6	24316.723	2280.409	16.6	5.07	1215.836	202.7
400	225	9.0.0	14.0.0	6.3	97.27	76.4	27338.074	2660.072	16.8	5.23	1366.904	236.5
400	225	9.0.0	16.0.0	6.3	105.91	83.1	30295.142	3039.736	16.9	5.36	1514.757	270.2
400	225	12.0.0	16.0.0	8.4	117.57	92.3	31541.043	3042.799	16.4	5.09	1577.052	270.5
400	225	12.0.0	19.0.0	8.4	130.35	102.3	35797.678	3612.244	16.6	5.26	1789.884	321.1
400	250	6.0.0	9.0.0	5.0	68.42	53.7	19989.298	2344.438	17.1	5.85	999.465	187.6
400	250	6.0.0	12.0.0	5.0	83.06	65.2	25246.669	3125.677	17.4	6.13	1262.333	250.1
400	250	9.0.0	12.0.0	6.3	94.63	74.3	26575.603	3127.284	16.8	5.75	1328.780	250.2
400	250	9.0.0	14.0.0	6.3	104.27	81.9	29946.647	3648.093	16.9	5.91	1497.332	291.8
400	250	9.0.0	16.0.0	6.3	113.91	89.4	33245.969	4168.902	17.1	6.05	1662.298	333.5
400	250	12.0.0	16.0.0	8.4	125.57	98.6	34491.870	4171.966	16.6	5.76	1724.593	333.8
400	250	12.0.0	19.0.0	8.4	139.85	109.8	39248.109	4953.129	16.8	5.95	1962.405	396.3
400	275	6.0.0	9.0.0	5.0	72.92	57.2	21709.513	3120.219	17.3	6.54	1085.476	226.9
400	275	6.0.0	12.0.0	5.0	89.06	69.9	27505.549	4160.052	17.6	6.83	1375.277	302.5
400	275	9.0.0	12.0.0	6.3	100.63	79.0	28834.483	4161.659	16.9	6.43	1441.724	302.7
400	275	9.0.0	14.0.0	6.3	111.27	87.3	32555.220	4854.864	17.1	6.61	1627.761	353.1
400	275	9.0.0	16.0.0	6.3	121.91	95.7	36196.796	5548.069	17.2	6.75	1809.840	403.5
400	275	12.0.0	16.0.0	8.4	133.57	104.9	37442.697	5551.133	16.7	6.45	1872.135	403.7
400	275	12.0.0	19.0.0	8.4	149.35	117.2	42698.541	6590.890	16.9	6.64	2134.927	479.3
400	300	6.0.0	9.0.0	5.0	77.42	60.8	23429.728	4050.688	17.4	7.23	1171.486	270.0
400	300	6.0.0	12.0.0	5.0	95.06	74.6	29764.429	5400.677	17.7	7.54	1488.221	360.0
400	300	6.0.0	14.0.0	5.0	106.82	83.9	33876.822	6300.670	17.8	7.68	1693.841	420.0
400	300	9.0.0	12.0.0	6.3	106.63	83.7	31093.363	5402.284	17.1	7.12	1554.668	360.2
400	300	9.0.0	14.0.0	6.3	118.27	92.8	35163.794	6302.260	17.2	7.30	1758.190	420.2
400	300	9.0.0	16.0.0	6.3	129.91	102.0	39147.622	7202.236	17.4	7.45	1957.381	480.1
400	300	12.0.0	16.0.0	8.4	141.57	111.1	40393.523	7205.299	16.9	7.13	2019.676	480.4
400	300	12.0.0	19.0.0	8.4	158.85	124.7	46148.973	8555.213	17.0	7.34	2307.449	570.3
400	300	12.0.0	22.0.0	8.4	176.13	138.3	51716.762	9905.126	17.1	7.50	2585.838	660.3
400	300	12.0.0	25.0.0	8.4	193.41	151.8	57100.0	11255.040	17.2	7.63	2855.0	750.3
400	325	6.0.0	9.0.0	5.0	81.92	64.3	25149.943	5149.906	17.5	7.93	1257.497	316.9
400	325	6.0.0	12.0.0	5.0	101.06	79.3	32023.309	6866.302	17.8	8.24	1601.165	422.5
400	325	6.0.0	14.0.0	5.0	113.82	89.3	36485.396	8010.565	17.9	8.39	1824.270	493.0
400	325	9.0.0	12.0.0	6.3	112.63	88.4	33352.243	6867.909	17.2	7.81	1667.612	422.6



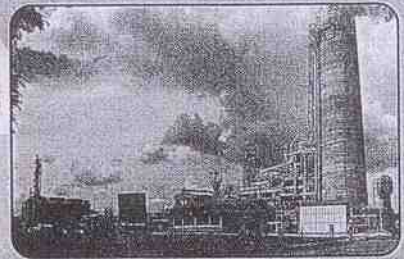
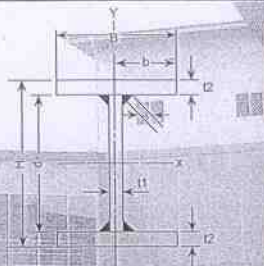
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
400	325	9.0.0	14.0.0	6.3	125.27	98.3	37772.367	8012.156	17.4	8.00	1888.618	493.1
400	325	9.0.0	16.0.0	6.3	137.91	108.3	42098.449	9156.402	17.5	8.15	2104.922	563.5
400	325	12.0.0	16.0.0	8.4	149.57	117.4	43344.350	9159.466	17.0	7.83	2167.217	563.7
400	325	12.0.0	19.0.0	8.4	168.35	132.2	49599.404	10875.786	17.2	8.04	2479.970	669.3
400	325	12.0.0	22.0.0	8.4	187.13	146.9	55650.508	12592.106	17.2	8.20	2782.525	774.9
400	325	12.0.0	25.0.0	8.4	205.91	161.6	61501.042	14308.425	17.3	8.34	3075.052	880.5
400	350	6.0.0	9.0.0	5.0	86.42	67.8	26870.158	6431.938	17.6	8.63	1343.508	367.5
400	350	6.0.0	12.0.0	5.0	107.06	84.0	34282.189	8575.677	17.9	8.95	1714.109	490.0
400	350	6.0.0	14.0.0	5.0	120.82	94.8	39093.969	10004.836	18.0	9.10	1954.698	571.7
400	350	9.0.0	12.0.0	6.3	118.63	93.1	35611.123	8577.284	17.3	8.50	1780.556	490.1
400	350	9.0.0	14.0.0	6.3	132.27	103.8	40380.940	10006.427	17.5	8.70	2019.047	571.8
400	350	9.0.0	16.0.0	6.3	145.91	114.5	45049.276	11435.569	17.6	8.85	2252.464	653.5
400	350	12.0.0	16.0.0	8.4	157.57	123.7	46295.177	11438.633	17.1	8.52	2314.759	653.6
400	350	12.0.0	19.0.0	8.4	177.85	139.6	53049.836	13582.296	17.3	8.74	2652.492	776.1
400	350	12.0.0	22.0.0	8.4	198.13	155.5	59584.255	15725.960	17.3	8.91	2979.213	898.6
400	350	12.0.0	25.0.0	8.4	218.41	171.5	65902.083	17869.623	17.4	9.05	3295.104	1021.1
400	375	6.0.0	9.0.0	5.0	90.92	71.4	28590.373	7910.844	17.7	9.33	1429.519	421.9
400	375	6.0.0	12.0.0	5.0	113.06	88.8	36541.069	10547.552	18.0	9.66	1827.053	562.5
400	375	6.0.0	14.0.0	5.0	127.82	100.3	41702.542	12305.357	18.1	9.81	2085.127	656.3
400	375	9.0.0	12.0.0	6.3	124.63	97.8	37870.003	10549.159	17.4	9.20	1893.50	562.6
400	375	9.0.0	14.0.0	6.3	139.27	109.3	42989.514	12306.947	17.6	9.40	2149.476	656.4
400	375	9.0.0	16.0.0	6.3	153.91	120.8	48000.102	14064.736	17.7	9.56	2400.005	750.1
400	375	12.0.0	16.0.0	8.4	165.57	130.0	49246.003	14067.799	17.2	9.22	2462.30	750.3
400	375	12.0.0	19.0.0	8.4	187.35	147.1	56500.268	16704.432	17.4	9.44	2825.013	890.9
400	375	12.0.0	22.0.0	8.4	209.13	164.2	63518.002	19341.064	17.4	9.62	3175.90	1031.5
400	375	12.0.0	25.0.0	8.4	230.91	181.3	70303.125	21977.696	17.4	9.76	3515.156	1172.1
400	400	6.0.0	9.0.0	5.0	95.42	74.9	30310.588	9600.688	17.8	10.03	1515.529	480.0
400	400	6.0.0	12.0.0	5.0	119.06	93.5	38799.949	12800.677	18.1	10.37	1939.997	640.0
400	400	6.0.0	14.0.0	5.0	134.82	105.8	44311.116	14934.003	18.1	10.52	2215.556	746.7
400	400	9.0.0	12.0.0	6.3	130.63	102.5	40128.883	12802.284	17.5	9.90	2006.444	640.1
400	400	9.0.0	14.0.0	6.3	146.27	114.8	45598.087	14935.593	17.7	10.10	2279.904	746.8
400	400	9.0.0	16.0.0	6.3	161.91	127.1	50950.929	17068.902	17.7	10.27	2547.546	853.4
400	400	12.0.0	16.0.0	8.4	173.57	136.3	52196.830	17071.966	17.3	9.92	2609.841	853.6
400	400	12.0.0	19.0.0	8.4	196.85	154.5	59950.699	20271.879	17.5	10.15	2997.535	1013.6
400	400	12.0.0	22.0.0	8.4	220.13	172.8	67451.748	23471.793	17.5	10.33	3372.587	1173.6
400	400	12.0.0	25.0.0	8.4	243.41	191.1	74704.167	26671.707	17.5	10.47	3735.208	1333.6

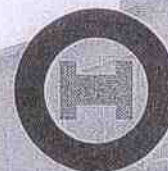
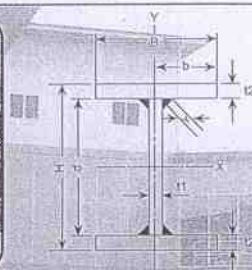


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

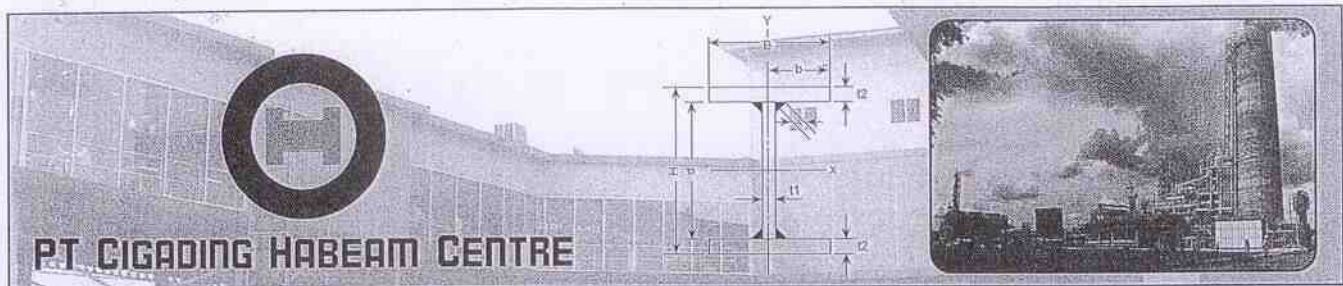
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
400	400	16.0.0	22.0.0	11.2	235.46	184.8	68955.682	23478.818	17.1	9.99	3447.784	1173.9
400	400	16.0.0	25.0.0	11.2	258.50	202.9	76133.333	26678.613	17.2	10.16	3806.667	1333.9
400	400	16.0.0	28.0.0	11.2	281.54	221.0	83069.065	29878.409	17.2	10.30	4153.453	1493.9
400	400	16.0.0	32.0.0	11.2	312.26	245.1	91947.554	34144.802	17.2	10.46	4597.378	1707.2
450	200	6.0.0	9.0.0	5.0	62.42	49.0	21536.798	1200.778	18.6	4.39	957.191	120.1
450	200	6.0.0	12.0.0	5.0	74.06	58.1	26892.479	1600.767	19.1	4.65	1195.221	160.1
450	200	9.0.0	12.0.0	6.3	87.13	68.4	28825.198	1602.588	18.2	4.29	1281.120	160.3
450	200	9.0.0	14.0.0	6.3	94.77	74.4	32258.945	1869.230	18.4	4.44	1433.731	186.9
450	200	9.0.0	16.0.0	6.3	102.41	80.4	35628.211	2135.873	18.7	4.57	1583.476	213.6
450	200	12.0.0	16.0.0	8.4	115.57	90.7	37454.077	2139.353	18.0	4.30	1664.626	213.9
450	200	12.0.0	19.0.0	8.4	126.85	99.6	42310.906	2539.266	18.3	4.47	1880.485	253.9
450	225	6.0.0	9.0.0	5.0	66.92	52.5	23725.013	1709.371	18.8	5.05	1054.445	151.9
450	225	6.0.0	12.0.0	5.0	80.06	62.8	29770.859	2278.892	19.3	5.34	1323.149	202.6
450	225	9.0.0	12.0.0	6.3	93.13	73.1	31703.578	2280.713	18.5	4.95	1409.048	202.7
450	225	9.0.0	14.0.0	6.3	101.77	79.9	35586.769	2660.376	18.7	5.11	1581.634	236.5
450	225	9.0.0	16.0.0	6.3	110.41	86.7	39397.037	3040.039	18.9	5.25	1750.979	270.2
450	225	12.0.0	16.0.0	8.4	123.57	97.0	41222.903	3043.519	18.3	4.96	1832.129	270.5
450	225	12.0.0	19.0.0	8.4	136.35	107.0	46725.588	3612.964	18.5	5.15	2076.693	321.2
450	250	6.0.0	9.0.0	5.0	71.42	56.1	25913.228	2344.528	19.0	5.73	1151.699	187.6
450	250	6.0.0	12.0.0	5.0	86.06	67.6	32649.239	3125.767	19.5	6.03	1451.077	250.1
450	250	9.0.0	12.0.0	6.3	99.13	77.8	34581.958	3127.588	18.7	5.62	1536.976	250.2
450	250	9.0.0	14.0.0	6.3	108.77	85.4	38914.592	3648.397	18.9	5.79	1729.537	291.9
450	250	9.0.0	16.0.0	6.3	118.41	93.0	43165.864	4169.206	19.1	5.93	1918.483	333.5
450	250	12.0.0	16.0.0	8.4	131.57	103.3	44991.730	4172.686	18.5	5.63	1999.632	333.8
450	250	12.0.0	19.0.0	8.4	145.85	114.5	51140.269	4953.849	18.7	5.83	2272.901	396.3
450	275	6.0.0	9.0.0	5.0	75.92	59.6	28101.443	3120.309	19.2	6.41	1248.953	226.9
450	275	6.0.0	12.0.0	5.0	92.06	72.3	35527.619	4160.142	19.6	6.72	1579.005	302.6
450	275	9.0.0	12.0.0	6.3	105.13	82.5	37460.338	4161.963	18.9	6.29	1664.904	302.7
450	275	9.0.0	14.0.0	6.3	115.77	90.9	42242.415	4855.168	19.1	6.48	1877.441	353.1
450	275	9.0.0	16.0.0	6.3	126.41	99.2	46934.691	5548.373	19.3	6.62	2085.986	403.5
450	275	12.0.0	16.0.0	8.4	139.57	109.6	48760.557	5551.853	18.7	6.31	2167.136	403.8
450	275	12.0.0	19.0.0	8.4	155.35	122.0	55554.951	6591.610	18.9	6.51	2469.109	479.4
450	300	6.0.0	9.0.0	5.0	80.42	63.1	30289.658	4050.778	19.4	7.10	1346.207	270.1
450	300	6.0.0	12.0.0	5.0	98.06	77.0	38405.999	5400.767	19.8	7.42	1706.933	360.1
450	300	6.0.0	14.0.0	5.0	109.82	86.2	43691.452	6300.760	19.9	7.57	1941.842	420.1



PT CIGADING HABEAM CENTRE

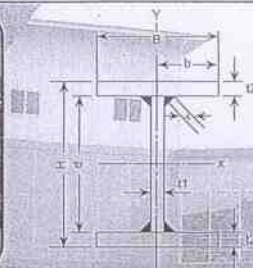
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
450	300	9.0.0	12.0.0	6.3	111.13	87.2	40338.718	5402.588	19.1	6.97	1792.832	360.2
450	300	9.0.0	14.0.0	6.3	122.77	96.4	45570.239	6302.564	19.3	7.16	2025.344	420.2
450	300	9.0.0	16.0.0	6.3	134.41	105.5	50703.517	7202.539	19.4	7.32	2253.490	480.2
450	300	12.0.0	16.0.0	8.4	147.57	115.8	52529.383	7206.019	18.9	6.99	2334.639	480.4
450	300	12.0.0	19.0.0	8.4	164.85	129.4	59969.633	8555.933	19.1	7.20	2665.317	570.4
450	300	12.0.0	22.0.0	8.4	182.13	143.0	67196.302	9905.846	19.2	7.37	2986.502	660.4
450	300	12.0.0	25.0.0	8.4	199.41	156.5	74212.50	11255.760	19.3	7.51	3298.333	750.4
450	325	6.0.0	9.0.0	5.0	84.92	66.7	32477.873	5149.996	19.6	7.79	1443.461	316.9
450	325	6.0.0	12.0.0	5.0	104.06	81.7	41284.379	6866.392	19.9	8.12	1834.861	422.5
450	325	6.0.0	14.0.0	5.0	116.82	91.7	47019.276	8010.655	20.1	8.28	2089.746	493.0
450	325	9.0.0	12.0.0	6.3	117.13	92.0	43217.098	6868.213	19.2	7.66	1920.760	422.7
450	325	9.0.0	14.0.0	6.3	129.77	101.9	48898.062	8012.459	19.4	7.86	2173.247	493.1
450	325	9.0.0	16.0.0	6.3	142.41	111.8	54472.344	9156.706	19.6	8.02	2420.993	563.5
450	325	12.0.0	16.0.0	8.4	155.57	122.1	56298.210	9160.186	19.0	7.67	2502.143	563.7
450	325	12.0.0	19.0.0	8.4	174.35	136.9	64384.314	10876.506	19.2	7.90	2861.525	669.3
450	325	12.0.0	22.0.0	8.4	193.13	151.6	72238.298	12592.826	19.3	8.07	3210.591	774.9
450	325	12.0.0	25.0.0	8.4	211.91	166.4	79863.542	14309.145	19.4	8.22	3549.491	880.6
450	350	6.0.0	9.0.0	5.0	89.42	70.2	34666.088	6432.028	19.7	8.48	1540.715	367.5
450	350	6.0.0	12.0.0	5.0	110.06	86.4	44162.759	8575.767	20.0	8.83	1962.789	490.0
450	350	6.0.0	14.0.0	5.0	123.82	97.2	50347.099	10004.926	20.2	8.99	2237.649	571.7
450	350	9.0.0	12.0.0	6.3	123.13	96.7	46095.478	8577.588	19.3	8.35	2048.688	490.1
450	350	9.0.0	14.0.0	6.3	136.77	107.4	52225.885	10006.730	19.5	8.55	2321.150	571.8
450	350	9.0.0	16.0.0	6.3	150.41	118.1	58241.171	11435.873	19.7	8.72	2588.496	653.5
450	350	12.0.0	16.0.0	8.4	163.57	128.4	60067.037	11439.353	19.2	8.36	2669.646	653.7
450	350	12.0.0	19.0.0	8.4	183.85	144.3	68798.996	13583.016	19.3	8.60	3057.733	776.2
450	350	12.0.0	22.0.0	8.4	204.13	160.2	77280.295	15726.680	19.5	8.78	3434.680	898.7
450	350	12.0.0	25.0.0	8.4	224.41	176.2	85514.583	17870.343	19.5	8.92	3800.648	1021.2
450	375	6.0.0	9.0.0	5.0	93.92	73.7	36854.303	7910.934	19.8	9.18	1637.969	421.9
450	375	6.0.0	12.0.0	5.0	116.06	91.1	47041.139	10547.642	20.1	9.53	2090.717	562.5
450	375	6.0.0	14.0.0	5.0	130.82	102.7	53674.922	12305.447	20.3	9.70	2385.552	656.3
450	375	9.0.0	12.0.0	6.3	129.13	101.4	48973.858	10549.463	19.5	9.04	2176.616	562.6
450	375	9.0.0	14.0.0	6.3	143.77	112.9	55553.709	12307.251	19.7	9.25	2469.054	656.4
450	375	9.0.0	16.0.0	6.3	158.41	124.4	62009.997	14065.039	19.8	9.42	2756.0	750.1
450	375	12.0.0	16.0.0	8.4	171.57	134.7	63835.863	14068.519	19.3	9.06	2837.149	750.3
450	375	12.0.0	19.0.0	8.4	193.35	151.8	73213.678	16705.152	19.5	9.30	3253.941	890.9
450	375	12.0.0	22.0.0	8.4	215.13	168.9	82322.292	19341.784	19.6	9.48	3658.769	1031.6
450	375	12.0.0	25.0.0	8.4	236.91	186.0	91165.625	21978.416	19.6	9.63	4051.806	1172.2



UKURAN DAN SIFAT-SIFAT PENAMPANG

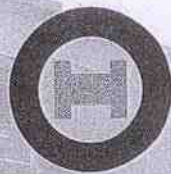
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
450	400	6.0.0	9.0.0	5.0	98.42	77.3	39042.518	9600.778	19.9	9.88	1735.223	480.0
450	400	6.0.0	12.0.0	5.0	122.06	95.8	49919.519	12800.767	20.2	10.24	2218.645	640.0
450	400	6.0.0	14.0.0	5.0	137.82	108.2	57002.746	14934.093	20.3	10.41	2533.455	746.7
450	400	9.0.0	12.0.0	6.3	135.13	106.1	51852.238	12802.588	19.6	9.73	2304.544	640.1
450	400	9.0.0	14.0.0	6.3	150.77	118.4	58881.532	14935.897	19.8	9.95	2616.957	746.8
450	400	9.0.0	16.0.0	6.3	166.41	130.6	65778.824	17069.206	19.9	10.13	2923.503	853.5
450	400	12.0.0	12.0.0	8.4	148.53	116.6	53784.958	12806.134	19.0	9.29	2390.443	640.3
450	400	12.0.0	16.0.0	8.4	179.57	141.0	67604.690	17072.686	19.4	9.75	3004.653	853.6
450	400	12.0.0	19.0.0	8.4	202.85	159.2	77628.359	20272.599	19.6	10.00	3450.149	1013.6
450	400	12.0.0	22.0.0	8.4	226.13	177.5	87364.288	23472.513	19.7	10.19	3882.857	1173.6
450	400	12.0.0	25.0.0	8.4	249.41	195.8	96816.667	26672.427	19.7	10.34	4302.963	1333.6
450	425	6.0.0	9.0.0	5.0	102.92	80.8	41230.733	11515.621	20.0	10.58	1832.477	541.9
450	425	6.0.0	12.0.0	5.0	128.06	100.5	52797.899	15353.892	20.3	10.95	2346.573	722.5
450	425	6.0.0	14.0.0	5.0	144.82	113.7	60330.569	17912.739	20.4	11.12	2681.359	843.0
450	425	9.0.0	12.0.0	6.3	141.13	110.8	54730.618	15355.713	19.7	10.43	2432.472	722.6
450	425	9.0.0	14.0.0	6.3	157.77	123.9	62209.355	17914.543	19.9	10.66	2764.860	843.0
450	425	9.0.0	16.0.0	6.3	174.41	136.9	69547.651	20473.373	20.0	10.83	3091.007	963.5
450	425	12.0.0	12.0.0	8.4	154.53	121.3	56663.338	15359.259	19.1	9.97	2518.371	722.8
450	425	12.0.0	16.0.0	8.4	187.57	147.2	71373.517	20476.853	19.5	10.45	3172.156	963.6
450	425	12.0.0	19.0.0	8.4	212.35	166.7	82043.041	24315.047	19.7	10.70	3646.357	1144.2
450	425	12.0.0	20.0.0	8.4	220.61	173.2	85531.267	25594.446	19.7	10.77	3801.390	1204.4
450	425	12.0.0	25.0.0	8.4	261.91	205.6	102467.708	31991.437	19.8	11.05	4554.120	1505.5
450	450	6.0.0	9.0.0	5.0	107.42	84.3	43418.948	13669.528	20.1	11.28	1929.731	607.5
450	450	6.0.0	12.0.0	5.0	134.06	105.2	55676.279	18225.767	20.4	11.66	2474.501	810.0
450	450	6.0.0	14.0.0	5.0	151.82	119.2	63658.392	21263.260	20.5	11.83	2829.262	945.0
450	450	9.0.0	12.0.0	6.3	147.13	115.5	57608.998	18227.588	19.8	11.13	2560.40	810.1
450	450	9.0.0	14.0.0	6.3	164.77	129.3	65537.179	21265.064	19.9	11.36	2912.763	945.1
450	450	9.0.0	16.0.0	6.3	182.41	143.2	73316.477	24302.539	20.0	11.54	3258.510	1080.1
450	450	12.0.0	12.0.0	8.4	160.53	126.0	59541.718	18231.134	19.3	10.66	2646.299	810.3
450	450	12.0.0	16.0.0	8.4	195.57	153.5	75142.343	24306.019	19.6	11.15	3339.660	1080.3
450	450	12.0.0	19.0.0	8.4	221.85	174.2	86457.723	28862.183	19.7	11.41	3842.565	1282.8
450	450	12.0.0	22.0.0	8.4	248.13	194.8	97448.282	33418.346	19.8	11.61	4331.035	1485.3
450	450	12.0.0	25.0.0	8.4	274.41	215.4	108118.750	37974.510	19.8	11.76	4805.278	1687.8
500	200	6.0.0	9.0.0	5.0	65.42	51.4	27298.728	1200.868	20.4	4.28	1091.949	120.1
500	200	6.0.0	12.0.0	5.0	77.06	60.5	33975.549	1600.857	21.0	4.56	1359.022	160.1
500	200	6.0.0	14.0.0	5.0	84.82	66.6	38334.289	1867.516	21.3	4.69	1533.372	186.8
500	200	9.0.0	12.0.0	6.3	91.63	71.9	36671.803	1602.892	20.0	4.18	1466.872	160.3



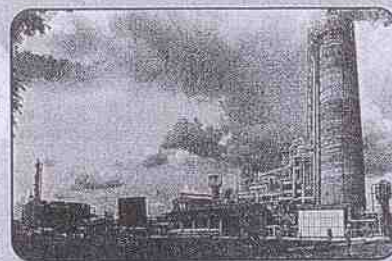
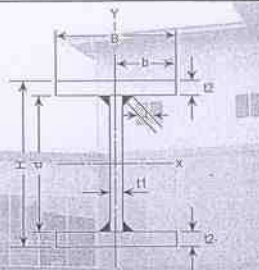
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
500	200	9.0.0	14.0.0	6.3	99.27	77.9	40963.140	1869.534	20.3	4.34	1638.526	187.0
500	200	9.0.0	16.0.0	6.3	106.91	83.9	45182.356	2136.176	20.6	4.47	1807.294	213.6
500	200	12.0.0	16.0.0	8.4	121.57	95.4	47744.937	2140.073	19.8	4.20	1909.797	214.0
500	200	12.0.0	19.0.0	8.4	132.85	104.3	53842.566	2539.986	20.1	4.37	2153.703	254.0
500	200	12.0.0	22.0.0	8.4	144.13	113.1	59783.855	2939.90	20.4	4.52	2391.354	294.0
500	200	12.0.0	25.0.0	8.4	155.41	122.0	65570.833	3339.813	20.5	4.64	2622.833	334.0
500	225	6.0.0	9.0.0	5.0	69.92	54.9	30011.193	1709.461	20.7	4.94	1200.448	152.0
500	225	6.0.0	12.0.0	5.0	83.06	65.2	37548.429	2278.982	21.3	5.24	1501.937	202.6
500	225	6.0.0	14.0.0	5.0	91.82	72.1	42468.862	2658.662	21.5	5.38	1698.754	236.3
500	225	9.0.0	12.0.0	6.3	97.63	76.6	40244.683	2281.017	20.3	4.83	1609.787	202.8
500	225	9.0.0	14.0.0	6.3	106.27	83.4	45097.714	2660.680	20.6	5.00	1803.909	236.5
500	225	9.0.0	16.0.0	6.3	114.91	90.2	49869.182	3040.343	20.8	5.14	1994.767	270.3
500	225	12.0.0	16.0.0	8.4	129.57	101.7	52431.763	3044.239	20.1	4.85	2097.271	270.6
500	225	12.0.0	19.0.0	8.4	142.35	111.7	59340.248	3613.684	20.4	5.04	2373.610	321.2
500	225	12.0.0	22.0.0	8.4	155.13	121.8	66071.602	4183.129	20.6	5.19	2642.864	371.8
500	225	12.0.0	25.0.0	8.4	167.91	131.8	72628.125	4752.574	20.8	5.32	2905.125	422.5
500	250	6.0.0	9.0.0	5.0	74.42	58.4	32723.658	2344.618	21.0	5.61	1308.946	187.6
500	250	6.0.0	12.0.0	5.0	89.06	69.9	41121.309	3125.857	21.5	5.92	1644.852	250.1
500	250	6.0.0	14.0.0	5.0	98.82	77.6	46603.436	3646.683	21.7	6.07	1864.137	291.7
500	250	9.0.0	12.0.0	6.3	103.63	81.4	43817.563	3127.892	20.6	5.49	1752.703	250.2
500	250	9.0.0	14.0.0	6.3	113.27	88.9	49232.287	3648.701	20.8	5.68	1969.291	291.9
500	250	9.0.0	16.0.0	6.3	122.91	96.5	54556.009	4169.510	21.1	5.82	2182.240	333.6
500	250	9.0.0	19.0.0	6.3	137.37	107.8	62372.651	4950.723	21.3	6.00	2494.906	396.1
500	250	12.0.0	16.0.0	8.4	137.57	108.0	57118.590	4173.406	20.4	5.51	2284.744	333.9
500	250	12.0.0	19.0.0	8.4	151.85	119.2	64837.929	4954.569	20.7	5.71	2593.517	396.4
500	250	12.0.0	22.0.0	8.4	166.13	130.4	72359.348	5735.733	20.9	5.88	2894.374	458.9
500	250	12.0.0	25.0.0	8.4	180.41	141.6	79685.417	6516.897	21.0	6.01	3187.417	521.4
500	275	6.0.0	9.0.0	5.0	78.92	62.0	35436.123	3120.399	21.2	6.29	1417.445	226.9
500	275	6.0.0	12.0.0	5.0	95.06	74.6	44694.189	4160.232	21.7	6.62	1787.768	302.6
500	275	6.0.0	14.0.0	5.0	105.82	83.1	50738.009	4853.454	21.9	6.77	2029.520	353.0
500	275	9.0.0	12.0.0	6.3	109.63	86.1	47390.443	4162.267	20.8	6.16	1895.618	302.7
500	275	9.0.0	14.0.0	6.3	120.27	94.4	53366.860	4855.472	21.1	6.35	2134.674	353.1
500	275	9.0.0	16.0.0	6.3	130.91	102.8	59242.836	5548.676	21.3	6.51	2369.713	403.5
500	275	9.0.0	19.0.0	6.3	146.87	115.3	67870.333	6588.484	21.5	6.70	2714.813	479.2
500	275	12.0.0	16.0.0	8.4	145.57	114.3	61805.417	5552.573	20.6	6.18	2472.217	403.8

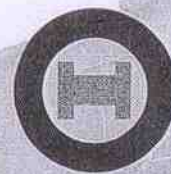
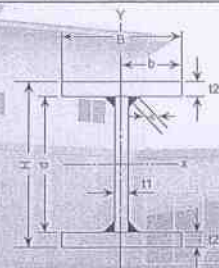


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

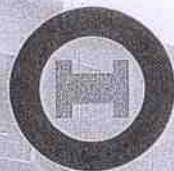
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
500	275	12.0.0	19.0.0	8.4	161.35	126.7	70335.611	6592.330	20.9	6.39	2813.424	479.4
500	275	12.0.0	22.0.0	8.4	177.13	139.0	78647.095	7632.087	21.1	6.56	3145.884	555.1
500	275	12.0.0	25.0.0	8.4	192.91	151.4	86742.708	8671.845	21.2	6.70	3469.708	630.7
500	300	6.0.0	9.0.0	5.0	83.42	65.5	38148.588	4050.868	21.4	6.97	1525.944	270.1
500	300	6.0.0	12.0.0	5.0	101.06	79.3	48267.069	5400.857	21.9	7.31	1930.683	360.1
500	300	6.0.0	14.0.0	5.0	112.82	88.6	54872.582	6300.850	22.1	7.47	2194.903	420.1
500	300	9.0.0	12.0.0	6.3	115.63	90.8	50963.323	5402.892	21.0	6.84	2038.533	360.2
500	300	9.0.0	14.0.0	6.3	127.27	99.9	57501.434	6302.867	21.3	7.04	2300.057	420.2
500	300	9.0.0	16.0.0	6.3	138.91	109.0	63929.662	7202.843	21.5	7.20	2557.186	480.2
500	300	9.0.0	19.0.0	6.3	156.37	122.8	73368.015	8552.807	21.7	7.40	2934.721	570.2
500	300	9.0.0	22.0.0	6.3	174.02	136.5	82564.371	9902.770	21.8	7.55	3302.575	660.2
500	300	9.0.0	25.0.0	6.3	191.48	150.2	91521.875	11252.734	21.9	7.67	3660.875	750.2
500	300	12.0.0	19.0.0	8.4	170.85	134.1	75833.293	8556.653	21.1	7.08	3033.332	570.4
500	300	12.0.0	22.0.0	8.4	188.13	147.7	84934.842	9906.566	21.2	7.26	3397.394	660.4
500	300	12.0.0	25.0.0	8.4	205.41	161.2	93800.0	11256.480	21.4	7.40	3752.0	750.4
500	300	16.0.0	25.0.0	11.2	224.51	176.2	96837.50	11265.360	20.8	7.08	3873.50	751.0
500	300	16.0.0	28.0.0	11.2	241.54	189.6	105349.491	12615.155	20.9	7.23	4213.980	841.0
500	300	16.0.0	32.0.0	11.2	264.26	207.5	116346.274	14414.882	21.0	7.39	4653.851	961.0
500	325	6.0.0	9.0.0	5.0	87.92	69.0	40861.053	5150.086	21.6	7.65	1634.442	316.9
500	325	6.0.0	12.0.0	5.0	107.06	84.0	51839.949	6866.482	22.0	8.01	2073.598	422.6
500	325	6.0.0	14.0.0	5.0	119.82	94.1	59007.156	8010.745	22.2	8.18	2360.286	493.0
500	325	9.0.0	12.0.0	6.3	121.63	95.5	54536.203	6868.517	21.2	7.51	2181.448	422.7
500	325	9.0.0	14.0.0	6.3	134.27	105.4	61636.007	8012.763	21.4	7.72	2465.440	493.1
500	325	9.0.0	16.0.0	6.3	146.91	115.3	68616.489	9157.010	21.6	7.89	2744.660	563.5
500	325	9.0.0	19.0.0	6.3	165.87	130.2	78865.696	10873.380	21.8	8.10	3154.628	669.1
500	325	9.0.0	22.0.0	6.3	185.02	145.1	88852.118	12589.749	21.9	8.25	3554.085	774.8
500	325	9.0.0	25.0.0	6.3	203.98	160.0	98579.167	14306.119	22.0	8.38	3943.167	880.4
500	325	12.0.0	19.0.0	8.4	180.35	141.6	81330.974	10877.226	21.2	7.77	3253.239	669.4
500	325	12.0.0	22.0.0	8.4	199.13	156.3	91222.588	12593.546	21.4	7.95	3648.904	775.0
500	325	12.0.0	25.0.0	8.4	217.91	171.1	100857.292	14309.865	21.5	8.10	4034.292	880.6
500	325	16.0.0	25.0.0	11.2	237.00	186.1	103894.792	14318.745	20.9	7.77	4155.792	881.2
500	325	16.0.0	28.0.0	11.2	255.54	200.6	113156.078	16034.947	21.0	7.92	4526.243	986.8
500	325	16.0.0	32.0.0	11.2	280.26	220.0	125120.887	18323.215	21.1	8.09	5004.835	1127.6
500	350	6.0.0	9.0.0	5.0	92.42	72.5	43573.518	6432.118	21.7	8.34	1742.941	367.5
500	350	6.0.0	12.0.0	5.0	113.06	88.8	55412.829	8575.857	22.1	8.71	2216.513	490.0
500	350	6.0.0	14.0.0	5.0	126.82	99.6	63141.729	10005.016	22.3	8.88	2525.669	571.7
500	350	9.0.0	12.0.0	6.3	127.63	100.2	58109.083	8577.892	21.3	8.20	2324.363	490.2
500	350	9.0.0	14.0.0	6.3	141.27	110.9	65770.580	10007.034	21.6	8.42	2630.823	571.8



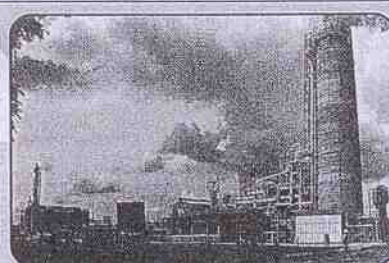
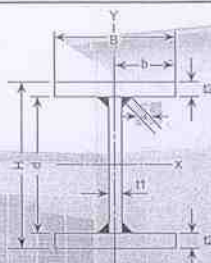
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
500	350	9.0.0	16.0.0	6.3	154.91	121.6	73303.316	11436.176	21.8	8.59	2932.133	653.5
500	350	9.0.0	19.0.0	6.3	175.37	137.7	84363.378	13579.890	21.9	8.80	3374.535	776.0
500	350	9.0.0	22.0.0	6.3	196.02	153.7	95139.865	15723.604	22.0	8.96	3805.595	898.5
500	350	9.0.0	25.0.0	6.3	216.48	169.8	105636.458	17867.317	22.1	9.09	4225.458	1021.0
500	350	12.0.0	16.0.0	8.4	169.57	133.1	75865.897	11440.073	21.2	8.21	3034.636	653.7
500	350	12.0.0	19.0.0	8.4	189.85	149.0	86828.656	13583.736	21.4	8.46	3473.146	776.2
500	350	12.0.0	22.0.0	8.4	210.13	165.0	97510.335	15727.40	21.5	8.65	3900.413	898.7
500	350	12.0.0	25.0.0	8.4	230.41	180.9	107914.583	17871.063	21.6	8.81	4316.583	1021.2
500	350	16.0.0	25.0.0	11.2	249.50	195.9	110952.083	17879.943	21.1	8.47	4438.083	1021.7
500	350	16.0.0	28.0.0	11.2	269.54	211.6	120962.665	20023.489	21.2	8.62	4838.507	1144.2
500	350	16.0.0	32.0.0	11.2	296.26	232.6	133895.501	22881.549	21.3	8.79	5355.820	1307.5
500	375	6.0.0	9.0.0	5.0	96.92	76.1	46285.983	7911.024	21.9	9.03	1851.439	421.9
500	375	6.0.0	12.0.0	5.0	119.06	93.5	58985.709	10547.732	22.3	9.41	2359.428	562.5
500	375	6.0.0	14.0.0	5.0	133.82	105.0	67276.302	12305.537	22.4	9.59	2691.052	656.3
500	375	9.0.0	12.0.0	6.3	133.63	104.9	61681.963	10549.767	21.5	8.89	2467.279	562.7
500	375	9.0.0	14.0.0	6.3	148.27	116.4	69905.154	12307.555	21.7	9.11	2796.206	656.4
500	375	9.0.0	16.0.0	6.3	162.91	127.9	77990.142	14065.343	21.9	9.29	3119.606	750.2
500	375	9.0.0	19.0.0	6.3	184.87	145.1	89861.060	16702.025	22.0	9.50	3594.442	890.8
500	375	9.0.0	22.0.0	6.3	206.83	162.4	101427.611	19338.708	22.1	9.67	4057.104	1031.4
500	375	9.0.0	25.0.0	6.3	228.79	179.6	112693.750	21975.390	22.2	9.80	4507.750	1172.0
500	375	12.0.0	16.0.0	8.4	177.57	139.4	80552.723	14069.239	21.3	8.90	3222.109	750.4
500	375	12.0.0	19.0.0	8.4	199.35	156.5	92326.338	16705.872	21.5	9.15	3693.054	891.0
500	375	12.0.0	22.0.0	8.4	221.13	173.6	103798.082	19342.504	21.7	9.35	4151.923	1031.6
500	375	12.0.0	25.0.0	8.4	242.91	190.7	114971.875	21979.136	21.8	9.51	4598.875	1172.2
500	375	16.0.0	25.0.0	11.2	262.01	205.7	118009.375	21988.016	21.2	9.16	4720.375	1172.7
500	375	16.0.0	28.0.0	11.2	283.55	222.6	128769.251	24624.530	21.3	9.32	5150.770	1313.3
500	375	16.0.0	32.0.0	11.2	312.27	245.1	142670.114	28139.882	21.4	9.49	5706.805	1500.8
500	400	6.0.0	14.0.0	5.0	140.82	110.5	71410.876	14934.183	22.5	10.30	2856.435	746.7
500	400	9.0.0	16.0.0	6.3	170.91	134.2	82676.969	17069.510	22.0	9.99	3307.079	853.5
500	400	9.0.0	19.0.0	6.3	194.37	152.6	95358.741	20269.473	22.1	10.21	3814.350	1013.5
500	400	12.0.0	12.0.0	8.4	154.53	121.3	67951.098	12806.854	21.0	9.10	2718.044	640.3
500	400	12.0.0	14.0.0	8.4	170.05	133.5	76668.578	14940.130	21.2	9.37	3066.743	747.0
500	400	12.0.0	16.0.0	8.4	185.57	145.7	85239.550	17073.406	21.4	9.59	3409.582	853.7
500	400	12.0.0	19.0.0	8.4	208.85	163.9	97824.019	20273.319	21.6	9.85	3912.961	1013.7
500	400	12.0.0	22.0.0	8.4	232.13	182.2	110085.828	23473.233	21.8	10.06	4403.433	1173.7
500	400	12.0.0	25.0.0	8.4	255.41	200.5	122029.167	26673.147	21.9	10.22	4881.167	1333.7
500	400	16.0.0	19.0.0	11.2	228.42	179.3	101111.057	20282.436	21.0	9.42	4044.442	1014.1
500	400	16.0.0	22.0.0	11.2	251.46	197.4	113246.455	23482.231	21.2	9.66	4529.858	1174.1
500	400	16.0.0	25.0.0	11.2	274.50	215.5	125066.667	26682.027	21.3	9.86	5002.667	1334.1

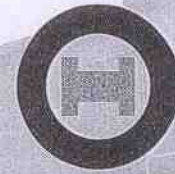
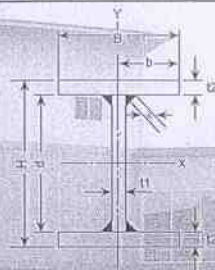


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

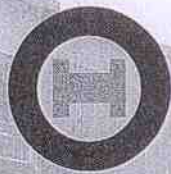
SIZE OF H-BEAM (mm)					AREA OF SECTION	WEIGHT PER METER	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
500	400	16.0.0	28.0.0	11.2	297.54	233.6	136575.838	29881.822	21.4	10.02	5463.034	1494.1
500	400	16.0.0	32.0.0	11.2	328.26	257.7	151444.727	34148.215	21.5	10.20	6057.789	1707.4
500	425	6.0.0	14.0.0	5.0	147.82	116.0	75545.449	17912.829	22.6	11.01	3021.818	843.0
500	425	9.0.0	16.0.0	6.3	178.91	140.4	87363.796	20473.676	22.1	10.70	3494.552	963.5
500	425	9.0.0	19.0.0	6.3	203.87	160.0	100856.423	24311.921	22.2	10.92	4034.257	1144.1
500	425	12.0.0	12.0.0	8.4	160.53	126.0	71523.978	15359.979	21.1	9.78	2860.959	722.8
500	425	12.0.0	14.0.0	8.4	177.05	139.0	80803.151	17918.776	21.4	10.06	3232.126	843.2
500	425	12.0.0	16.0.0	8.4	193.57	152.0	89926.377	20477.573	21.6	10.29	3597.055	963.7
500	425	12.0.0	19.0.0	8.4	218.35	171.4	103321.701	24315.767	21.8	10.55	4132.868	1144.3
500	425	12.0.0	22.0.0	8.4	243.13	190.9	116373.575	28153.962	21.9	10.76	4654.943	1324.9
500	425	12.0.0	25.0.0	8.4	267.91	210.3	129086.458	31992.157	22.0	10.93	5163.458	1505.5
500	425	16.0.0	19.0.0	11.2	237.93	186.8	106608.739	24324.884	21.2	10.11	4264.350	1144.7
500	425	16.0.0	22.0.0	11.2	262.46	206.0	119534.202	28162.961	21.3	10.36	4781.368	1325.3
500	425	16.0.0	25.0.0	11.2	287.00	225.3	132123.958	32001.037	21.5	10.56	5284.958	1505.9
500	425	16.0.0	28.0.0	11.2	311.54	244.6	144382.425	35839.114	21.5	10.73	5775.297	1686.5
500	425	16.0.0	32.0.0	11.2	344.26	270.3	160219.341	40956.549	21.6	10.91	6408.774	1927.4
500	450	6.0.0	14.0.0	5.0	154.82	121.5	79680.022	21263.350	22.7	11.72	3187.201	945.0
500	450	9.0.0	16.0.0	6.3	186.91	146.7	92050.622	24302.843	22.2	11.40	3682.025	1080.1
500	450	9.0.0	19.0.0	6.3	213.37	167.5	106354.105	28859.057	22.3	11.63	4254.164	1282.6
500	450	12.0.0	12.0.0	8.4	166.53	130.7	75096.858	18231.854	21.2	10.46	3003.874	810.3
500	450	12.0.0	14.0.0	8.4	184.05	144.5	84937.725	21269.297	21.5	10.75	3397.509	945.3
500	450	12.0.0	16.0.0	8.4	201.57	158.2	94613.203	24306.739	21.7	10.98	3784.528	1080.3
500	450	12.0.0	19.0.0	8.4	227.84	178.9	108819.383	28862.903	21.9	11.25	4352.775	1282.8
500	450	12.0.0	22.0.0	8.4	254.13	199.5	122661.322	33419.066	22.0	11.47	4906.453	1485.3
500	450	12.0.0	25.0.0	8.4	280.41	220.1	136143.750	37975.230	22.0	11.64	5445.750	1687.8
500	450	16.0.0	19.0.0	11.2	247.42	194.2	112106.420	28872.020	21.3	10.80	4484.257	1283.2
500	450	16.0.0	22.0.0	11.2	273.46	214.7	125821.949	33428.065	21.4	11.06	5032.878	1485.7
500	450	16.0.0	25.0.0	11.2	299.50	235.1	139181.250	37984.110	21.6	11.26	5567.250	1688.2
500	450	16.0.0	28.0.0	11.2	325.54	255.6	152189.011	42540.155	21.6	11.43	6087.560	1890.7
500	450	16.0.0	32.0.0	11.2	360.26	282.8	168993.954	48614.882	21.7	11.62	6759.758	2160.7
500	475	6.0.0	14.0.0	5.0	161.82	127.0	83814.596	25007.620	22.8	12.43	3352.584	1053.0
500	475	9.0.0	16.0.0	6.3	194.91	153.0	96737.449	28582.010	22.3	12.11	3869.498	1203.5
500	475	9.0.0	19.0.0	6.3	222.87	175.0	111851.786	33940.567	22.4	12.34	4474.071	1429.1
500	475	12.0.0	12.0.0	8.4	172.53	135.4	78669.738	21441.229	21.4	11.15	3146.790	902.8
500	475	12.0.0	14.0.0	8.4	191.05	150.0	89072.298	25013.568	21.6	11.44	3562.892	1053.2
500	475	12.0.0	16.0.0	8.4	209.57	164.5	99300.030	28585.906	21.8	11.68	3972.001	1203.6
500	475	12.0.0	19.0.0	8.4	237.35	186.3	114317.064	33944.413	21.9	11.96	4572.683	1429.2
500	475	12.0.0	22.0.0	8.4	265.13	208.1	128949.068	39302.921	22.1	12.18	5157.963	1654.9



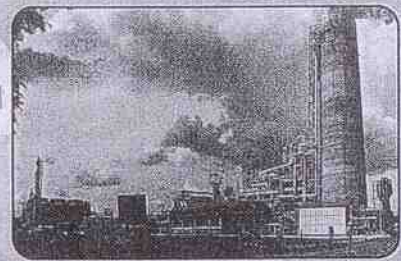
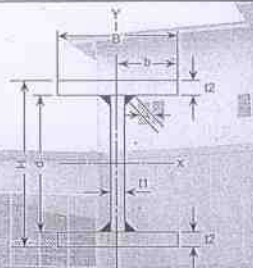
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
500	475	12.0.0	25.0.0	8.4	292.91	229.9	143201.042	44661.428	22.1	12.35	5728.042	1880.5
500	475	16.0.0	19.0.0	11.2	256.92	201.7	117604.102	33953.530	21.4	11.50	4704.164	1429.6
500	475	16.0.0	22.0.0	11.2	284.46	223.3	132109.695	39311.919	21.6	11.76	5284.388	1655.2
500	475	16.0.0	25.0.0	11.2	312.00	244.9	146238.542	44670.308	21.6	11.97	5849.542	1880.9
500	475	16.0.0	28.0.0	11.2	339.54	266.5	159995.598	50028.697	21.7	12.14	6399.824	2106.5
500	475	16.0.0	32.0.0	11.2	376.26	295.4	177768.567	57173.215	21.7	12.33	7110.743	2407.3
500	500	9.0.0	16.0.0	6.3	202.91	159.3	101424.276	33336.176	22.4	12.82	4056.971	1333.4
500	500	12.0.0	16.0.0	8.4	217.57	170.8	103986.857	33340.073	21.9	12.38	4159.474	1333.6
500	500	12.0.0	19.0.0	8.4	246.85	193.8	119814.746	39589.986	22.0	12.66	4792.590	1583.6
500	500	12.0.0	22.0.0	8.4	276.13	216.8	135236.815	45839.90	22.1	12.88	5409.473	1833.6
500	500	12.0.0	25.0.0	8.4	305.41	239.7	150258.333	52089.813	22.2	13.06	6010.333	2083.6
500	500	16.0.0	16.0.0	11.2	237.38	186.4	107403.631	33349.308	21.3	11.85	4296.145	1334.0
500	500	16.0.0	19.0.0	11.2	266.42	209.1	123101.784	39599.103	21.5	12.19	4924.071	1584.0
500	500	16.0.0	22.0.0	11.2	295.46	231.9	138397.442	45848.898	21.6	12.46	5535.898	1834.0
500	500	16.0.0	25.0.0	11.2	324.50	254.7	153295.833	52098.693	21.7	12.67	6131.833	2083.9
500	500	16.0.0	28.0.0	11.2	353.54	277.5	167802.185	58348.489	21.8	12.85	6712.087	2333.9
500	500	16.0.0	32.0.0	11.2	392.26	307.9	186543.181	66681.549	21.8	13.04	7461.727	2667.3
500	500	19.0.0	19.0.0	13.3	281.70	220.8	125567.062	39609.740	21.1	11.87	5022.682	1584.4
500	500	19.0.0	22.0.0	13.3	310.56	243.5	140767.913	45859.398	21.3	12.16	5630.717	1834.4
500	500	19.0.0	25.0.0	13.3	339.42	266.1	155573.958	52109.055	21.4	12.40	6222.958	2084.4
500	500	19.0.0	28.0.0	13.3	368.38	288.8	169990.394	58358.712	21.5	12.59	6799.616	2334.3
500	500	19.0.0	32.0.0	13.3	406.76	319.0	188615.227	66691.588	21.5	12.81	7544.609	2667.7
550	200	6.0.0	9.0.0	5.0	68.42	53.7	33872.158	1200.958	22.2	4.19	1231.715	120.1
550	200	6.0.0	12.0.0	5.0	80.06	62.8	42015.619	1600.947	22.9	4.47	1527.841	160.1
550	200	6.0.0	14.0.0	5.0	87.82	68.9	47342.419	1867.606	23.2	4.61	1721.543	186.8
550	200	9.0.0	12.0.0	6.3	96.13	75.5	45653.908	1603.195	21.8	4.08	1660.142	160.3
550	200	9.0.0	14.0.0	6.3	103.77	81.5	50898.335	1869.838	22.1	4.24	1850.849	187.0
550	200	9.0.0	16.0.0	6.3	111.41	87.5	56063.001	2136.480	22.4	4.38	2038.655	213.6
550	200	12.0.0	16.0.0	8.4	127.57	100.1	59537.797	2140.793	21.6	4.10	2165.011	214.1
550	200	12.0.0	19.0.0	8.4	138.85	109.0	67017.226	2540.706	22.0	4.28	2436.990	254.1
550	200	12.0.0	22.0.0	8.4	150.13	117.9	74323.395	2940.620	22.2	4.43	2702.669	294.1
550	200	12.0.0	25.0.0	8.4	161.41	126.7	81458.333	3340.533	22.5	4.55	2962.121	334.1
550	250	6.0.0	9.0.0	5.0	77.42	60.8	40458.088	2344.708	22.9	5.50	1471.203	187.6
550	250	6.0.0	12.0.0	5.0	92.06	72.3	50700.379	3125.947	23.5	5.83	1843.650	250.1
550	250	6.0.0	14.0.0	5.0	101.82	79.9	57400.066	3646.773	23.7	5.98	2087.275	291.7
550	250	9.0.0	12.0.0	6.3	108.13	84.9	54338.668	3128.195	22.4	5.38	1975.952	250.3
550	250	9.0.0	14.0.0	6.3	117.77	92.5	60955.982	3649.004	22.8	5.57	2216.581	291.9
550	250	9.0.0	16.0.0	6.3	127.41	100.0	67472.654	4169.814	23.0	5.72	2453.551	333.6

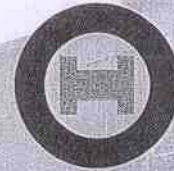
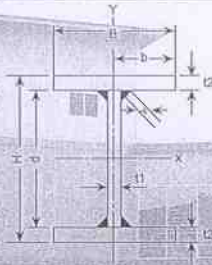


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

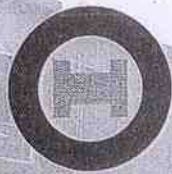
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
550	250	9.0.0	19.0.0	6.3	141.87	111.4	77060.646	4951.027	23.3	5.91	2802.205	396.1
550	250	12.0.0	16.0.0	8.4	143.57	112.7	70947.450	4174.126	22.2	5.39	2579.907	333.9
550	250	12.0.0	19.0.0	8.4	157.85	123.9	80416.089	4955.289	22.6	5.60	2924.221	396.4
550	250	12.0.0	22.0.0	8.4	172.13	135.1	89665.388	5736.453	22.8	5.77	3260.560	458.9
550	250	12.0.0	25.0.0	8.4	186.41	146.3	98697.917	6517.617	23.0	5.91	3589.015	521.4
550	300	6.0.0	9.0.0	5.0	86.42	67.8	47044.018	4050.958	23.3	6.85	1710.692	270.1
550	300	6.0.0	12.0.0	5.0	104.06	81.7	59385.139	5400.947	23.9	7.20	2159.460	360.1
550	300	6.0.0	14.0.0	5.0	115.82	90.9	67457.712	6300.940	24.1	7.38	2453.008	420.1
550	300	9.0.0	12.0.0	6.3	120.13	94.3	63023.428	5403.195	22.9	6.71	2291.761	360.2
550	300	9.0.0	14.0.0	6.3	131.77	103.4	71013.629	6303.171	23.2	6.92	2582.314	420.2
550	300	9.0.0	16.0.0	6.3	143.41	112.6	78882.307	7203.147	23.5	7.09	2868.448	480.2
550	300	9.0.0	19.0.0	6.3	160.87	126.3	90459.510	8553.110	23.7	7.29	3289.437	570.2
550	300	12.0.0	16.0.0	8.4	159.57	125.3	82357.103	7207.459	22.7	6.72	2994.804	480.5
550	300	12.0.0	19.0.0	8.4	176.85	138.8	93814.953	8557.373	23.0	6.96	3411.453	570.5
550	300	12.0.0	22.0.0	8.4	194.13	152.4	105007.382	9907.286	23.3	7.14	3818.450	660.5
550	300	12.0.0	25.0.0	8.4	211.41	166.0	115937.50	11257.20	23.4	7.30	4215.909	750.5
550	350	6.0.0	9.0.0	5.0	95.42	74.9	53629.948	6432.208	23.7	8.21	1950.180	367.6
550	350	6.0.0	12.0.0	5.0	116.06	91.1	68069.899	8575.947	24.2	8.60	2475.269	490.1
550	350	6.0.0	14.0.0	5.0	129.82	101.9	77515.359	10005.106	24.4	8.78	2818.740	571.7
550	350	9.0.0	12.0.0	6.3	132.13	103.7	71708.188	8578.195	23.3	8.06	2607.570	490.2
550	350	9.0.0	14.0.0	6.3	145.77	114.4	81071.275	10007.338	23.6	8.29	2948.046	571.8
550	350	9.0.0	16.0.0	6.3	159.41	125.1	90291.961	11436.480	23.8	8.47	3283.344	653.5
550	350	9.0.0	19.0.0	6.3	179.87	141.2	103858.373	13580.194	24.0	8.69	3776.668	776.0
550	350	9.0.0	22.0.0	6.3	200.52	157.3	117110.520	15723.907	24.2	8.86	4258.564	898.5
550	350	9.0.0	25.0.0	6.3	220.98	173.3	130052.083	17867.621	24.3	9.00	4729.167	1021.0
550	350	12.0.0	16.0.0	8.4	175.57	137.8	93766.757	11440.793	23.1	8.07	3409.70	653.8
550	350	12.0.0	19.0.0	8.4	195.85	153.7	107213.816	13584.456	23.4	8.33	3898.684	776.3
550	350	12.0.0	22.0.0	8.4	216.13	169.7	120349.375	15728.120	23.6	8.53	4376.341	898.7
550	350	12.0.0	25.0.0	8.4	236.41	185.6	133177.083	17871.783	23.7	8.69	4842.803	1021.2
550	350	16.0.0	25.0.0	11.2	257.50	202.1	137343.750	17881.650	23.1	8.33	4994.318	1021.8
550	350	16.0.0	28.0.0	11.2	277.54	217.9	149719.051	20025.195	23.2	8.49	5444.329	1144.3
550	350	16.0.0	32.0.0	11.2	304.26	238.9	165758.087	22883.255	23.3	8.67	6027.567	1307.6
550	400	9.0.0	16.0.0	6.3	175.41	137.7	101701.614	17069.814	24.1	9.86	3698.241	853.5
550	400	9.0.0	19.0.0	6.3	198.87	156.1	117257.236	20269.777	24.3	10.10	4263.90	1013.5
550	400	12.0.0	12.0.0	8.4	160.53	126.0	84031.238	12807.574	22.9	8.93	3055.681	640.4
550	400	12.0.0	16.0.0	8.4	191.57	150.4	105176.410	17074.126	23.4	9.44	3824.597	853.7
550	400	12.0.0	19.0.0	8.4	214.85	168.7	120612.679	20274.039	23.7	9.71	4385.916	1013.7
550	400	12.0.0	22.0.0	8.4	238.13	186.9	135691.368	23473.953	23.9	9.93	4934.232	1173.7



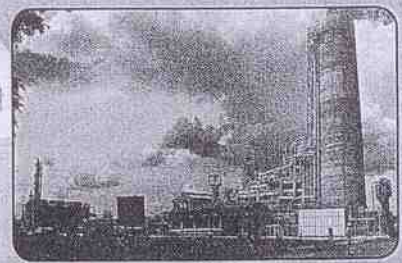
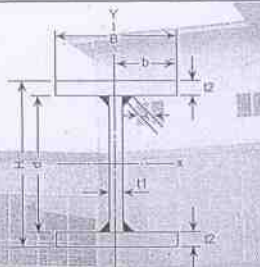
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
550	400	12.0.0	25.0.0	8.4	261.41	205.2	150416.667	26673.867	24.0	10.10	5469.697	1333.7
550	400	16.0.0	19.0.0	11.2	236.42	185.6	125086.604	20284.143	23.0	9.26	4548.604	1014.2
550	400	16.0.0	22.0.0	11.2	259.46	203.7	140009.842	23483.938	23.2	9.51	5091.267	1174.2
550	400	16.0.0	25.0.0	11.2	282.50	221.8	154583.333	26683.733	23.4	9.72	5621.212	1334.2
550	400	16.0.0	28.0.0	11.2	305.54	239.9	168811.225	29883.529	23.5	9.89	6138.590	1494.2
550	400	16.0.0	32.0.0	11.2	336.26	264.0	187251.314	34149.922	23.6	10.08	6809.139	1707.5
600	200	6.0.0	9.0.0	5.0	71.42	56.1	41294.588	1201.048	24.0	4.10	1376.486	120.1
600	200	6.0.0	12.0.0	5.0	83.06	65.2	51050.189	1601.037	24.8	4.39	1701.673	160.1
600	200	6.0.0	16.0.0	5.0	98.68	77.4	63745.135	2134.356	25.4	4.65	2124.838	213.4
600	200	6.0.0	19.0.0	5.0	110.44	86.5	73034.670	2534.345	25.7	4.80	2434.489	253.4
600	200	9.0.0	12.0.0	6.3	100.63	79.0	55827.763	1603.499	23.6	3.99	1860.925	160.3
600	200	9.0.0	16.0.0	6.3	115.91	91.0	68326.396	2136.784	24.3	4.29	2277.547	213.7
600	200	9.0.0	19.0.0	6.3	127.37	100.0	77472.278	2536.747	24.7	4.46	2582.409	253.7
600	200	9.0.0	22.0.0	6.3	139.02	109.0	86424.945	2936.711	25.0	4.60	2880.831	293.7
600	200	12.0.0	16.0.0	8.4	133.57	104.9	72907.657	2141.513	23.4	4.00	2430.255	214.2
600	200	12.0.0	19.0.0	8.4	144.85	113.7	81909.886	2541.426	23.8	4.19	2730.330	254.1
600	200	12.0.0	22.0.0	8.4	156.13	122.6	90721.935	2941.340	24.1	4.34	3024.064	294.1
600	200	12.0.0	25.0.0	8.4	167.41	131.4	99345.833	3341.253	24.4	4.47	3311.528	334.1
600	250	6.0.0	9.0.0	5.0	80.42	63.1	49154.018	2344.798	24.7	5.40	1638.467	187.6
600	250	6.0.0	12.0.0	5.0	95.06	74.6	61423.949	3126.037	25.4	5.73	2047.465	250.1
600	250	6.0.0	16.0.0	5.0	114.68	89.9	77390.788	4167.689	26.0	6.03	2579.693	333.4
600	250	6.0.0	19.0.0	5.0	129.44	101.4	89074.533	4948.928	26.3	6.19	2969.151	395.9
600	250	9.0.0	12.0.0	6.3	112.63	88.4	66201.523	3128.499	24.2	5.27	2206.717	250.3
600	250	9.0.0	16.0.0	6.3	131.91	103.6	81972.049	4170.117	24.9	5.62	2732.402	333.6
600	250	9.0.0	19.0.0	6.3	146.37	114.9	93512.141	4951.331	25.3	5.82	3117.071	396.1
600	250	9.0.0	22.0.0	6.3	161.02	126.3	104808.438	5732.544	25.5	5.97	3493.615	458.6
600	250	12.0.0	16.0.0	8.4	149.57	117.4	86553.310	4174.846	24.1	5.28	2885.110	334.0
600	250	12.0.0	19.0.0	8.4	163.85	128.6	97949.749	4956.009	24.4	5.50	3264.992	396.5
600	250	12.0.0	22.0.0	8.4	178.13	139.8	109105.428	5737.173	24.7	5.68	3636.848	459.0
600	250	12.0.0	25.0.0	8.4	192.41	151.0	120022.917	6518.337	25.0	5.82	4000.764	521.5
600	300	6.0.0	9.0.0	5.0	89.42	70.2	57013.448	4051.048	25.3	6.73	1900.448	270.1
600	300	6.0.0	12.0.0	5.0	107.06	84.0	71797.709	5401.037	25.9	7.10	2393.257	360.1
600	300	6.0.0	16.0.0	5.0	130.68	102.5	91036.442	7201.022	26.4	7.43	3034.548	480.1
600	300	6.0.0	19.0.0	5.0	148.44	116.4	105114.396	8551.012	26.6	7.60	3503.813	570.1
600	300	9.0.0	12.0.0	6.3	124.63	97.8	76575.283	5403.499	24.8	6.58	2552.509	360.2
600	300	9.0.0	16.0.0	6.3	147.91	116.1	95617.702	7203.451	25.4	6.98	3187.257	480.2
600	300	9.0.0	19.0.0	6.3	165.37	129.8	109552.005	8553.414	25.7	7.19	3651.733	570.2
600	300	9.0.0	22.0.0	6.3	183.02	143.5	123191.931	9903.378	26.0	7.36	4106.398	660.2

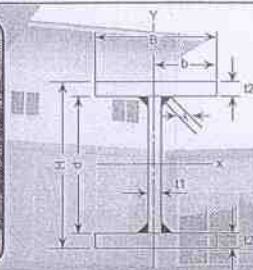
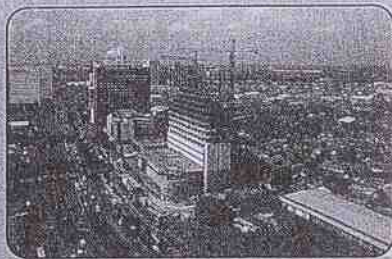


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

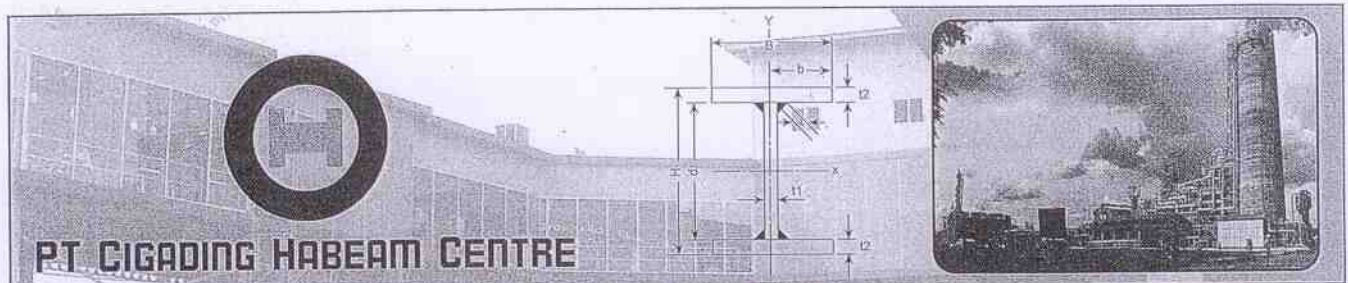
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
600	300	12.0.0	16.0.0	8.4	165.57	130.0	100198.963	7208.179	24.6	6.60	3339.965	480.5
600	300	12.0.0	19.0.0	8.4	183.85	143.5	113989.613	8558.093	25.0	6.84	3799.654	570.5
600	300	12.0.0	22.0.0	8.4	200.13	157.1	127488.922	9908.006	25.2	7.04	4249.631	660.5
600	300	12.0.0	25.0.0	8.4	217.41	170.7	140700.0	11257.920	25.4	7.20	4690.0	750.5
600	350	6.0.0	9.0.0	5.0	98.42	77.3	64872.878	6432.298	25.7	8.08	2162.429	367.6
600	350	6.0.0	12.0.0	5.0	119.06	93.5	82171.469	8576.037	26.3	8.49	2739.049	490.1
600	350	6.0.0	16.0.0	5.0	146.68	115.1	104682.095	11434.356	26.7	8.83	3489.403	653.4
600	350	9.0.0	12.0.0	6.3	136.63	107.3	86949.043	8578.499	25.2	7.92	2898.301	490.2
600	350	9.0.0	16.0.0	6.3	163.91	128.7	109263.356	11436.784	25.8	8.35	3642.112	653.5
600	350	9.0.0	19.0.0	6.3	184.37	144.7	125591.868	13580.497	26.1	8.58	4186.396	776.0
600	350	9.0.0	22.0.0	6.3	205.02	160.8	141575.425	15724.211	26.3	8.76	4719.181	898.5
600	350	12.0.0	16.0.0	8.4	181.57	142.5	113844.617	11441.513	25.0	7.94	3794.821	653.8
600	350	12.0.0	19.0.0	8.4	201.85	158.5	130029.476	13585.176	25.4	8.20	4334.316	776.3
600	350	12.0.0	22.0.0	8.4	222.13	174.4	145872.415	15728.840	25.6	8.41	4862.414	898.8
600	350	12.0.0	25.0.0	8.4	242.41	190.3	161377.083	17872.503	25.8	8.59	5379.236	1021.3
600	400	6.0.0	9.0.0	5.0	107.42	84.3	72732.308	9601.048	26.0	9.45	2424.410	480.1
600	400	6.0.0	12.0.0	5.0	131.06	102.9	92545.229	12801.037	26.6	9.88	3084.841	640.1
600	400	6.0.0	16.0.0	5.0	162.68	127.6	118327.748	17067.689	27.0	10.25	3944.258	853.4
600	400	9.0.0	12.0.0	6.3	148.63	116.7	97322.803	12803.499	25.6	9.28	3244.093	640.2
600	400	9.0.0	16.0.0	6.3	179.91	141.2	122909.009	17070.117	26.1	9.74	4096.967	853.5
600	400	9.0.0	19.0.0	6.3	203.37	159.6	141631.731	20270.081	26.4	9.98	4721.058	1013.5
600	400	9.0.0	22.0.0	6.3	227.02	178.1	159958.918	23470.044	26.6	10.17	5331.964	1173.5
600	400	12.0.0	16.0.0	8.4	197.57	155.1	127490.270	17074.846	25.4	9.30	4249.676	853.7
600	400	12.0.0	19.0.0	8.4	220.85	173.4	146069.339	20274.759	25.7	9.58	4868.978	1013.7
600	400	12.0.0	22.0.0	8.4	244.13	191.6	164255.908	23474.673	25.9	9.81	5475.197	1173.7
600	400	12.0.0	25.0.0	8.4	267.41	209.9	182054.167	26674.587	26.1	9.99	6068.472	1333.7
650	200	6.0.0	9.0.0	5.0	74.42	58.4	49603.518	1201.138	25.8	4.02	1526.262	120.1
650	200	6.0.0	12.0.0	5.0	86.06	67.6	61116.759	1601.127	26.6	4.31	1880.516	160.1
650	200	6.0.0	16.0.0	5.0	101.58	79.7	76128.065	2134.446	27.4	4.58	2342.402	213.4
650	200	6.0.0	19.0.0	5.0	113.44	88.9	87134.50	2534.435	27.7	4.73	2681.062	253.4
650	200	9.0.0	12.0.0	6.3	105.13	82.5	67249.618	1603.803	25.3	3.91	2069.219	160.4
650	200	9.0.0	16.0.0	6.3	120.41	94.5	82028.791	2137.088	26.1	4.21	2523.963	213.7
650	200	9.0.0	19.0.0	6.3	131.87	103.5	92865.023	2537.051	26.5	4.39	2857.385	253.7
650	200	9.0.0	22.0.0	6.3	143.52	112.5	103490.850	2937.015	26.9	4.53	3184.334	293.7
650	200	12.0.0	16.0.0	8.4	139.57	109.6	87929.517	2142.233	25.1	3.92	2705.524	214.2
650	200	12.0.0	19.0.0	8.4	150.85	118.4	98595.546	2542.146	25.6	4.11	3033.709	254.2
650	200	12.0.0	22.0.0	8.4	162.13	127.3	109054.475	2942.060	25.9	4.26	3355.522	294.2
650	200	12.0.0	25.0.0	8.4	173.41	136.1	119308.333	3341.973	26.2	4.39	3671.026	334.2
650	200	12.0.0	28.0.0	8.4	184.69	145.0	129359.152	3741.887	26.5	4.50	3980.282	374.2



PT CIGADING HABEAM CENTRE

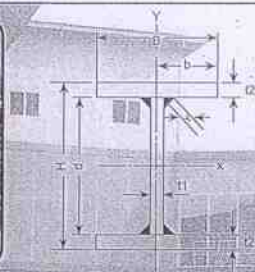
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
650	250	6.0.0	9.0.0	5.0	83.42	65.5	58848.948	2344.888	26.6	5.30	1810.737	187.6
650	250	6.0.0	12.0.0	5.0	98.06	77.0	73329.519	3126.127	27.3	5.65	2256.293	250.1
650	250	6.0.0	16.0.0	5.0	117.68	92.3	92209.718	4167.779	28.0	5.95	2837.222	333.4
650	250	6.0.0	19.0.0	5.0	132.44	103.8	106052.863	4949.018	28.3	6.12	3263.165	395.9
650	250	9.0.0	12.0.0	6.3	117.13	92.0	79462.378	3128.803	26.0	5.17	2444.996	250.3
650	250	9.0.0	16.0.0	6.3	136.41	107.1	98110.444	4170.421	26.8	5.53	3018.783	333.6
650	250	9.0.0	19.0.0	6.3	150.87	118.4	111783.386	4951.635	27.2	5.73	3439.489	396.1
650	250	9.0.0	22.0.0	6.3	165.52	129.8	125190.843	5732.848	27.5	5.89	3852.026	458.6
650	250	12.0.0	16.0.0	8.4	155.57	122.1	104011.170	4175.566	25.9	5.18	3200.344	334.0
650	250	12.0.0	19.0.0	8.4	169.85	133.3	117513.909	4956.729	26.3	5.40	3615.813	396.5
650	250	12.0.0	22.0.0	8.4	184.13	144.5	130754.468	5737.893	26.6	5.58	4023.214	459.0
650	250	12.0.0	25.0.0	8.4	198.41	155.8	143735.417	6519.057	26.9	5.73	4422.628	521.5
650	250	12.0.0	28.0.0	8.4	212.69	167.0	156459.325	7300.220	27.1	5.86	4814.133	584.0
650	250	12.0.0	32.0.0	8.4	231.73	181.9	173029.139	8341.772	27.3	6.00	5323.974	667.3
650	300	6.0.0	9.0.0	5.0	92.42	72.5	68094.378	4051.138	27.1	6.62	2095.212	270.1
650	300	6.0.0	12.0.0	5.0	110.06	86.4	85542.279	5401.127	27.9	7.01	2632.070	360.1
650	300	6.0.0	16.0.0	5.0	133.68	104.9	108291.372	7201.112	28.5	7.34	3332.042	480.1
650	300	6.0.0	19.0.0	5.0	151.44	118.7	124971.226	8551.102	28.7	7.52	3845.269	570.1
650	300	9.0.0	12.0.0	6.3	129.13	101.4	91675.138	5403.803	26.6	6.47	2820.773	360.3
650	300	9.0.0	16.0.0	6.3	152.41	119.6	114192.097	7203.754	27.4	6.87	3513.603	480.3
650	300	9.0.0	19.0.0	6.3	169.87	133.4	130701.750	8553.718	27.7	7.10	4021.592	570.2
650	300	9.0.0	22.0.0	6.3	187.52	147.1	146890.836	9903.681	28.0	7.27	4519.718	660.2
650	300	12.0.0	16.0.0	8.4	171.57	134.7	120092.823	7208.899	26.5	6.48	3695.164	480.6
650	300	12.0.0	19.0.0	8.4	188.85	148.2	136432.273	8558.813	26.9	6.73	4197.916	570.6
650	300	12.0.0	22.0.0	8.4	206.13	161.8	152454.462	9908.726	27.2	6.93	4690.907	660.6
650	300	12.0.0	25.0.0	8.4	223.41	175.4	168162.50	11258.640	27.4	7.10	5174.231	750.6
650	300	12.0.0	28.0.0	8.4	240.69	188.9	183559.498	12608.554	27.6	7.24	5647.985	840.6
650	300	12.0.0	32.0.0	8.4	263.73	207.0	203610.366	14408.438	27.8	7.39	6264.934	960.6
650	350	6.0.0	9.0.0	5.0	101.42	79.6	77339.808	6432.388	27.6	7.96	2379.686	367.6
650	350	6.0.0	12.0.0	5.0	122.06	95.8	97755.039	8576.127	28.3	8.38	3007.847	490.1
650	350	6.0.0	16.0.0	5.0	149.68	117.4	124373.025	11434.446	28.8	8.74	3826.862	653.4
650	350	9.0.0	12.0.0	6.3	141.13	110.8	103887.898	8578.803	27.1	7.80	3196.551	490.2
650	350	9.0.0	16.0.0	6.3	168.41	132.2	130273.751	11437.088	27.8	8.24	4008.423	653.5
650	350	9.0.0	19.0.0	6.3	188.87	148.3	149620.113	13580.801	28.1	8.48	4603.696	776.0
650	350	9.0.0	22.0.0	6.3	209.52	164.3	168590.830	15724.515	28.4	8.67	5187.410	898.5
650	350	12.0.0	16.0.0	8.4	187.57	147.2	136174.477	11442.233	26.9	7.81	4189.984	653.8
650	350	12.0.0	19.0.0	8.4	207.85	163.2	155350.636	13585.896	27.3	8.08	4780.020	776.3
650	350	12.0.0	22.0.0	8.4	228.13	179.1	174154.455	15729.560	27.6	8.30	5358.599	898.8
650	350	12.0.0	25.0.0	8.4	248.41	195.0	192589.583	17873.223	27.8	8.48	5925.833	1021.3



UKURAN DAN SIFAT-SIFAT PENAMPANG

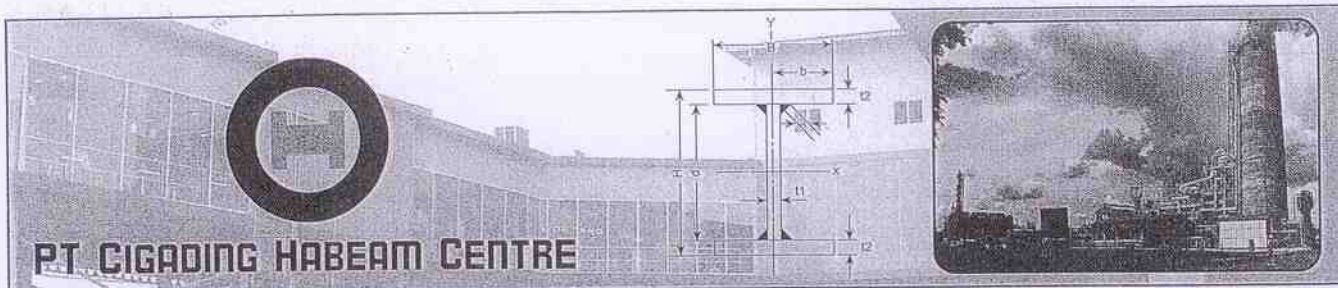
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			I _x	I _y	i _x	i _y	Z _x	Z _y
H	B	t 1	t 2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
650	350	12.0.0	28.0.0	8.4	268.69	210.9	210659.672	20016.887	28.0	8.63	6481.836	1143.8
650	350	12.0.0	32.0.0	8.4	295.73	232.1	234191.592	22875.105	28.1	8.79	7205.895	1307.1
650	400	6.0.0	9.0.0	5.0	110.42	86.7	86585.238	9601.138	28.0	9.32	2664.161	480.1
650	400	6.0.0	12.0.0	5.0	134.06	105.2	109967.799	12801.127	28.6	9.77	3383.625	640.1
650	400	6.0.0	16.0.0	5.0	165.68	130.0	140454.678	17067.779	29.1	10.15	4321.682	853.4
650	400	9.0.0	12.0.0	6.3	153.13	120.2	116100.658	12803.803	27.5	9.14	3572.328	640.2
650	400	9.0.0	16.0.0	6.3	184.41	144.8	146355.404	17070.421	28.2	9.62	4503.243	853.5
650	400	9.0.0	19.0.0	6.3	207.87	163.2	168538.476	20270.385	28.5	9.87	5185.799	1013.5
650	400	9.0.0	22.0.0	6.3	231.52	181.6	190290.823	23470.348	28.7	10.07	5855.102	1173.5
650	400	12.0.0	16.0.0	8.4	203.57	159.8	152256.130	17075.566	27.3	9.16	4684.804	853.8
650	400	12.0.0	19.0.0	8.4	226.85	178.1	174268.999	20275.479	27.7	9.45	5362.123	1013.8
650	400	12.0.0	22.0.0	8.4	250.13	196.4	195854.448	23475.393	28.0	9.69	6026.291	1173.8
650	400	12.0.0	25.0.0	8.4	273.41	214.6	217016.667	26675.307	28.2	9.88	6677.436	1333.8
650	400	12.0.0	28.0.0	8.4	296.69	232.9	237759.845	29875.220	28.3	10.03	7315.688	1493.8
650	400	12.0.0	32.0.0	8.4	327.73	257.3	264772.819	34141.772	28.4	10.21	8146.856	1707.1
700	200	6.0.0	9.0.0	5.0	77.42	60.8	58836.448	1201.228	27.6	3.94	1681.041	120.1
700	200	6.0.0	12.0.0	5.0	89.06	69.9	72252.829	1601.217	28.5	4.24	2064.367	160.1
700	200	6.0.0	16.0.0	5.0	104.68	82.1	89774.495	2134.536	29.3	4.52	2564.986	213.5
700	200	6.0.0	19.0.0	5.0	116.44	91.2	102643.330	2534.525	29.7	4.67	2932.667	253.5
700	200	9.0.0	12.0.0	6.3	109.63	86.1	79975.723	1604.107	27.0	3.83	2285.021	160.4
700	200	9.0.0	16.0.0	6.3	124.91	98.1	97226.436	2137.391	27.9	4.14	2777.898	213.7
700	200	9.0.0	19.0.0	6.3	136.37	107.1	109896.268	2537.355	28.4	4.31	3139.893	253.7
700	200	9.0.0	22.0.0	6.3	148.02	116.0	122338.505	2937.319	28.8	4.46	3495.386	293.7
700	200	9.0.0	25.0.0	6.3	159.48	125.0	134555.208	3337.282	29.1	4.58	3844.435	333.7
700	200	12.0.0	16.0.0	8.4	145.57	114.3	104678.377	2142.953	26.8	3.84	2990.811	214.3
700	200	12.0.0	19.0.0	8.4	156.85	123.1	117149.206	2542.866	27.3	4.03	3347.120	254.3
700	200	12.0.0	22.0.0	8.4	168.13	132.0	129396.015	2942.780	27.7	4.18	3697.029	294.3
700	200	12.0.0	25.0.0	8.4	179.41	140.8	141420.833	3342.693	28.1	4.32	4040.595	334.3
700	200	12.0.0	28.0.0	8.4	190.69	149.7	153225.692	3742.607	28.3	4.43	4377.877	374.3
700	200	12.0.0	32.0.0	8.4	205.73	161.5	168626.852	4275.825	28.6	4.56	4817.910	427.6
700	250	6.0.0	9.0.0	5.0	86.42	67.8	69580.378	2344.978	28.4	5.21	1988.011	187.6
700	250	6.0.0	12.0.0	5.0	101.06	79.3	86454.589	3126.217	29.2	5.56	2470.131	250.1
700	250	6.0.0	16.0.0	5.0	120.68	94.7	108492.148	4167.869	30.0	5.88	3099.776	333.4
700	250	6.0.0	19.0.0	5.0	135.44	106.1	124677.693	4949.108	30.4	6.05	3562.220	395.9
700	250	9.0.0	19.0.0	6.3	155.37	122.0	131930.631	4951.938	29.1	5.65	3769.447	396.2
700	250	9.0.0	12.0.0	6.3	121.63	95.5	94177.483	3129.107	27.8	5.07	2690.785	250.3
700	250	9.0.0	16.0.0	6.3	140.91	110.6	115944.089	4170.725	28.7	5.44	3312.688	333.7
700	250	9.0.0	19.0.0	6.3	155.37	122.0	131930.631	4951.938	29.1	5.65	3769.447	396.2



PT CIGADING HABEAM CENTRE

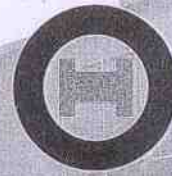
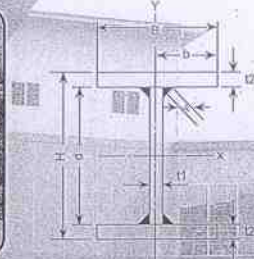
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION	WEIGHT PER METER	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
700	250	9.0.0	22.0.0	6.3	170.02	133.3	147629.998	5733.152	29.5	5.81	4218.0	458.7
700	250	9.0.0	25.0.0	6.3	184.48	144.7	163044.792	6514.365	29.7	5.95	4658.423	521.1
700	250	12.0.0	16.0.0	8.4	161.57	126.8	123396.030	4176.286	27.6	5.08	3525.601	334.1
700	250	12.0.0	19.0.0	8.4	175.85	138.0	139183.569	4957.449	28.1	5.31	3976.673	396.6
700	250	12.0.0	22.0.0	8.4	190.13	149.3	154687.508	5738.613	28.5	5.49	4419.643	459.1
700	250	12.0.0	25.0.0	8.4	204.41	160.5	169910.417	6519.777	28.8	5.65	4854.583	521.6
700	250	12.0.0	28.0.0	8.4	218.69	171.7	184854.865	7300.940	29.1	5.78	5281.568	584.1
700	250	12.0.0	32.0.0	8.4	237.73	186.6	204352.079	8342.492	29.3	5.92	5838.631	667.4
700	300	6.0.0	9.0.0	5.0	95.42	74.9	80324.308	4051.228	29.0	6.52	2294.980	270.1
700	300	6.0.0	12.0.0	5.0	113.06	88.8	100656.349	5401.217	29.8	6.91	2875.896	360.1
700	300	6.0.0	16.0.0	5.0	136.68	107.2	127209.802	7201.202	30.5	7.26	3634.566	480.1
700	300	6.0.0	19.0.0	5.0	154.44	121.1	146712.056	8551.192	30.8	7.45	4191.773	570.1
700	300	9.0.0	12.0.0	6.3	133.63	104.9	108379.243	5404.107	28.5	6.36	3096.550	360.3
700	300	9.0.0	16.0.0	6.3	156.91	123.2	134661.742	7204.058	29.3	6.78	3847.478	480.3
700	300	9.0.0	19.0.0	6.3	174.37	136.9	153964.995	8554.022	29.7	7.00	4399.0	570.3
700	300	9.0.0	22.0.0	6.3	192.02	150.6	172921.491	9903.985	30.0	7.19	4940.614	660.3
700	300	9.0.0	25.0.0	6.3	209.48	164.3	191534.375	11253.949	30.3	7.33	5472.411	750.3
700	300	12.0.0	16.0.0	8.4	177.57	139.4	142113.683	7209.619	28.3	6.37	4060.391	480.6
700	300	12.0.0	19.0.0	8.4	194.85	153.0	161217.933	8559.533	28.8	6.63	4606.227	570.6
700	300	12.0.0	22.0.0	8.4	212.13	166.5	179979.002	9909.446	29.1	6.83	5142.257	660.6
700	300	12.0.0	25.0.0	8.4	229.41	180.1	198400.0	11259.360	29.4	7.01	5668.571	750.6
700	300	12.0.0	28.0.0	8.4	246.69	193.7	216484.038	12609.274	29.6	7.15	6185.258	840.6
700	300	12.0.0	32.0.0	8.4	269.73	211.7	240077.306	14409.158	29.8	7.31	6859.352	960.6
700	350	6.0.0	9.0.0	5.0	104.42	82.0	91068.238	6432.478	29.5	7.85	2601.950	367.6
700	350	6.0.0	12.0.0	5.0	125.06	98.2	114858.109	8576.217	30.3	8.28	3281.660	490.1
700	350	6.0.0	16.0.0	5.0	152.68	119.8	145927.455	11434.536	30.9	8.66	4169.356	653.4
700	350	6.0.0	19.0.0	5.0	173.44	136.0	168746.420	13578.275	31.2	8.85	4821.326	775.9
700	350	9.0.0	12.0.0	6.3	145.63	114.3	122581.003	8579.107	29.0	7.68	3502.314	490.2
700	350	9.0.0	16.0.0	6.3	172.91	135.7	153379.396	11437.391	29.8	8.13	4382.268	653.6
700	350	9.0.0	19.0.0	6.3	193.37	151.8	175999.358	13581.105	30.2	8.38	5028.553	776.1
700	350	9.0.0	22.0.0	6.3	214.02	167.9	198212.985	15724.819	30.4	8.58	5663.228	898.6
700	350	9.0.0	25.0.0	6.3	234.48	183.9	220023.958	17868.532	30.6	8.73	6286.399	1021.1
700	350	12.0.0	16.0.0	8.4	193.57	152.0	160831.337	11442.953	28.8	7.69	4595.181	653.9
700	350	12.0.0	19.0.0	8.4	213.85	167.9	183252.296	13586.616	29.3	7.97	5235.780	776.4
700	350	12.0.0	22.0.0	8.4	234.13	183.8	205270.495	15730.280	29.6	8.20	5864.871	898.9
700	350	12.0.0	25.0.0	8.4	254.41	199.7	226889.583	17873.943	29.9	8.38	6482.560	1021.4
700	350	12.0.0	28.0.0	8.4	274.69	215.6	248113.212	20017.607	30.1	8.54	7088.949	1143.9
700	350	12.0.0	32.0.0	8.4	301.73	236.9	275802.532	22875.825	30.2	8.71	7880.072	1307.2



UKURAN DAN SIFAT-SIFAT PENAMPANG

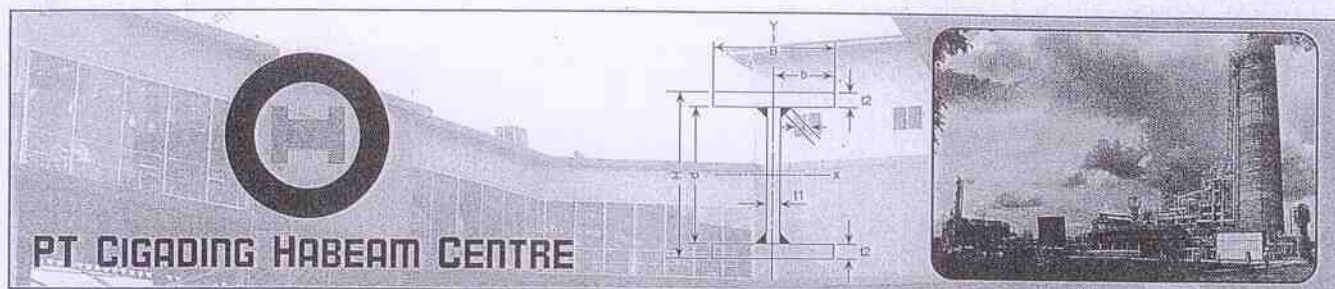
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
700	400	6.0.0	9.0.0	5.0	113.42	89.0	101812.168	9601.228	30.0	9.20	2908.919	480.1
700	400	6.0.0	12.0.0	5.0	137.06	107.6	129059.869	12801.217	30.7	9.66	3687.425	640.1
700	400	6.0.0	16.0.0	5.0	168.68	132.3	164645.108	17067.869	31.3	10.06	4704.146	853.4
700	400	6.0.0	19.0.0	5.0	192.44	150.9	190780.783	20267.858	31.5	10.27	5450.880	1013.4
700	400	9.0.0	12.0.0	6.3	157.63	123.7	136782.763	12804.107	29.5	9.01	3908.079	640.2
700	400	9.0.0	16.0.0	6.3	188.91	148.3	172097.049	17070.725	30.2	9.51	4917.059	853.5
700	400	9.0.0	19.0.0	6.3	212.37	166.7	198033.721	20270.688	30.5	9.77	5658.106	1013.5
700	400	9.0.0	22.0.0	6.3	236.02	185.1	223504.478	23470.652	30.8	9.98	6385.842	1173.5
700	400	9.0.0	25.0.0	6.3	259.48	203.5	248513.542	26670.615	31.0	10.14	7100.387	1333.5
700	400	12.0.0	16.0.0	8.4	209.57	164.5	179548.990	17076.286	29.3	9.03	5129.971	853.8
700	400	12.0.0	19.0.0	8.4	232.85	182.8	205286.659	20276.199	29.7	9.33	5865.333	1013.8
700	400	12.0.0	22.0.0	8.4	256.13	201.1	230561.988	23476.113	30.0	9.57	6587.485	1173.8
700	400	12.0.0	25.0.0	8.4	279.41	219.3	255379.167	26676.027	30.2	9.77	7296.548	1333.8
700	400	12.0.0	28.0.0	8.4	302.69	237.6	279742.385	29875.940	30.4	9.93	7992.640	1493.8
700	400	12.0.0	32.0.0	8.4	333.73	262.0	311527.759	34142.492	30.6	10.11	8900.793	1707.1
750	200	6.0.0	9.0.0	5.0	80.42	63.1	69030.878	1201.318	29.3	3.86	1840.823	120.1
750	200	6.0.0	12.0.0	5.0	92.06	72.3	84495.899	1601.307	30.3	4.17	2253.224	160.1
750	200	6.0.0	16.0.0	5.0	107.68	84.5	104721.925	2134.626	31.2	4.45	2792.585	213.5
750	200	6.0.0	19.0.0	5.0	119.44	93.6	119598.660	2534.615	31.7	4.61	3189.298	253.5
750	200	9.0.0	12.0.0	6.3	114.13	89.6	94062.328	1604.410	28.7	3.75	2508.329	160.4
750	200	9.0.0	16.0.0	6.3	129.41	101.6	113975.581	2137.695	29.7	4.06	3039.349	213.8
750	200	9.0.0	19.0.0	6.3	140.87	110.6	128622.263	2537.659	30.2	4.24	3429.927	253.8
750	200	9.0.0	22.0.0	6.3	152.52	119.6	143024.160	2937.622	30.6	4.39	3813.978	293.8
750	200	9.0.0	25.0.0	6.3	163.98	128.6	157183.333	3337.586	31.0	4.51	4191.556	333.8
750	200	12.0.0	16.0.0	8.4	151.57	119.0	123229.237	2143.673	28.5	3.76	3286.113	214.4
750	200	12.0.0	19.0.0	8.4	162.85	127.8	137645.866	2543.586	29.1	3.95	3670.556	254.4
750	200	12.0.0	22.0.0	8.4	174.13	136.7	151821.555	2943.50	29.5	4.11	4048.575	294.3
750	200	12.0.0	25.0.0	8.4	185.41	145.5	165758.333	3343.413	29.9	4.25	4420.222	334.3
750	200	12.0.0	28.0.0	8.4	196.69	154.4	179458.232	3743.327	30.2	4.36	4785.553	374.3
750	200	12.0.0	32.0.0	8.4	211.73	166.2	197359.792	4276.545	30.5	4.49	5262.928	427.7
750	250	6.0.0	9.0.0	5.0	89.42	70.2	81385.808	2345.068	30.2	5.12	2170.288	187.6
750	250	6.0.0	12.0.0	5.0	104.06	81.7	100836.659	3126.307	31.1	5.48	2688.978	250.1
750	250	6.0.0	16.0.0	5.0	123.68	97.0	126275.578	4167.959	32.0	5.81	3367.349	333.4
750	250	6.0.0	19.0.0	5.0	138.44	108.5	144986.523	4949.198	32.4	5.98	3866.307	395.9
750	250	9.0.0	12.0.0	6.3	126.13	99.0	110403.088	3129.410	29.6	4.98	2944.082	250.4
750	250	9.0.0	16.0.0	6.3	145.41	114.1	135529.234	4171.029	30.5	5.36	3614.113	333.7
750	250	9.0.0	19.0.0	6.3	159.87	125.5	154010.126	4952.242	31.0	5.57	4106.937	396.2
750	250	9.0.0	22.0.0	6.3	174.52	136.9	172182.153	5733.456	31.4	5.73	4591.524	458.7
750	250	9.0.0	25.0.0	6.3	188.98	148.2	190047.917	6514.669	31.7	5.87	5067.944	521.2



PT CIGADING HABEAN CENTRE

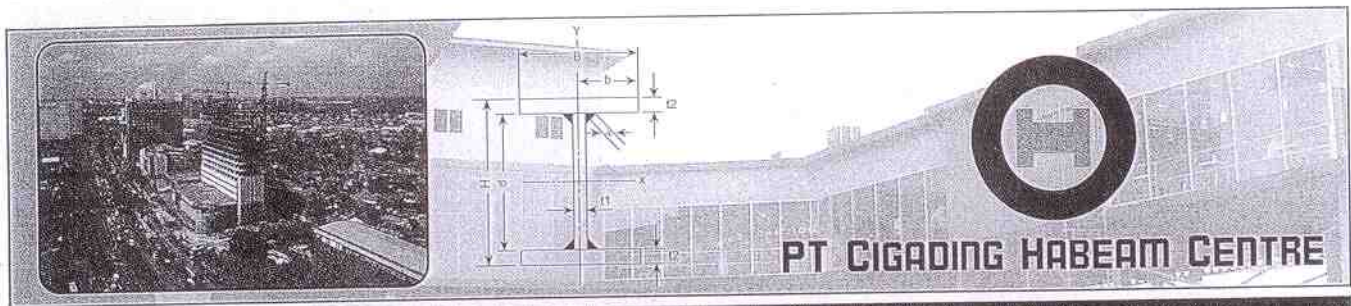
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
750	250	12.0.0	16.0.0	8.4	167.57	131.5	144782.890	4177.006	29.4	4.99	3860.877	334.2
750	250	12.0.0	19.0.0	8.4	181.85	142.8	163033.729	4958.169	29.9	5.22	4347.566	396.7
750	250	12.0.0	22.0.0	8.4	196.13	154.0	180979.548	5739.333	30.4	5.41	4826.121	459.1
750	250	12.0.0	25.0.0	8.4	210.41	165.2	198622.917	6520.497	30.7	5.57	5296.611	521.6
750	250	12.0.0	28.0.0	8.4	224.69	176.4	215966.405	7301.660	31.0	5.70	5759.104	584.1
750	250	12.0.0	32.0.0	8.4	243.73	191.3	238629.019	8343.212	31.3	5.85	6363.441	667.5
750	300	6.0.0	9.0.0	5.0	98.42	77.3	93740.738	4051.318	30.9	6.42	2499.753	270.1
750	300	6.0.0	12.0.0	5.0	116.06	91.1	117177.419	5401.307	31.8	6.82	3124.731	360.1
750	300	6.0.0	16.0.0	5.0	139.68	109.6	147829.232	7201.292	32.5	7.18	3942.113	480.1
750	300	6.0.0	19.0.0	5.0	157.44	123.4	170374.386	8551.282	32.9	7.37	4543.317	570.1
750	300	9.0.0	12.0.0	6.3	138.13	108.4	126743.848	5404.410	30.3	6.25	3379.836	360.3
750	300	9.0.0	16.0.0	6.3	161.41	126.7	157082.887	7204.362	31.2	6.68	4188.877	480.3
750	300	9.0.0	19.0.0	6.3	178.87	140.4	179397.990	8554.325	31.7	6.92	4783.946	570.3
750	300	9.0.0	22.0.0	6.3	196.52	154.1	201340.146	9904.289	32.0	7.10	5369.071	660.3
750	300	9.0.0	25.0.0	6.3	213.98	167.8	222912.50	11254.253	32.3	7.26	5944.333	750.3
750	300	12.0.0	16.0.0	8.4	183.57	144.1	166336.543	7210.339	30.1	6.27	4435.641	480.7
750	300	12.0.0	19.0.0	8.4	178.87	144.1	166336.543	7210.339	30.1	6.27	4435.641	480.7
750	300	12.0.0	22.0.0	8.4	218.13	171.2	210137.542	9910.166	31.0	6.74	5603.668	660.7
750	300	12.0.0	25.0.0	8.4	235.41	184.8	231487.50	11260.080	31.4	6.92	6173.0	750.7
750	300	12.0.0	28.0.0	8.4	252.69	198.4	252474.578	12609.994	31.6	7.06	6732.655	840.7
750	300	12.0.0	32.0.0	8.4	275.73	216.4	279898.246	14409.878	31.9	7.23	7463.953	960.7
750	350	6.0.0	9.0.0	5.0	107.42	84.3	106095.668	6432.568	31.4	7.74	2829.218	367.6
750	350	6.0.0	12.0.0	5.0	128.06	100.5	133518.179	8576.307	32.3	8.18	3560.485	490.1
750	350	6.0.0	16.0.0	5.0	155.68	122.1	169382.885	11434.626	33.0	8.57	4516.877	653.4
750	350	6.0.0	19.0.0	5.0	176.44	138.3	195762.250	13578.365	33.3	8.78	5220.327	775.9
750	350	9.0.0	12.0.0	6.3	150.13	117.9	143084.608	8579.410	30.9	7.56	3815.590	490.3
750	350	9.0.0	16.0.0	6.3	177.41	139.3	178636.541	11437.695	31.7	8.03	4763.641	653.6
750	350	9.0.0	19.0.0	6.3	197.87	155.3	204785.853	13581.409	32.2	8.28	5460.956	776.1
750	350	9.0.0	22.0.0	6.3	218.52	171.4	230498.140	15725.122	32.5	8.49	6146.617	898.6
750	350	9.0.0	25.0.0	6.3	238.98	187.5	255777.083	17868.836	32.7	8.65	6820.722	1021.1
750	350	12.0.0	16.0.0	8.4	199.57	156.7	187890.197	11443.673	30.7	7.57	5010.405	653.9
750	350	12.0.0	19.0.0	8.4	219.85	172.6	213809.456	13587.336	31.2	7.86	5701.585	776.4
750	350	12.0.0	22.0.0	8.4	240.13	188.5	239295.535	15731.0	31.6	8.09	6381.214	898.9
750	350	12.0.0	25.0.0	8.4	260.41	204.4	264352.083	17874.663	31.9	8.28	7049.389	1021.4
750	350	12.0.0	28.0.0	8.4	280.69	220.3	288982.752	20018.327	32.1	8.44	7706.207	1143.9
750	350	12.0.0	32.0.0	8.4	307.73	241.6	321167.472	22876.545	32.3	8.62	8564.466	1307.2
750	400	6.0.0	9.0.0	5.0	116.42	91.4	118450.598	9601.318	31.9	9.08	3158.683	480.1
750	400	6.0.0	12.0.0	5.0	140.06	109.9	149858.939	12801.307	32.7	9.56	3996.238	640.1



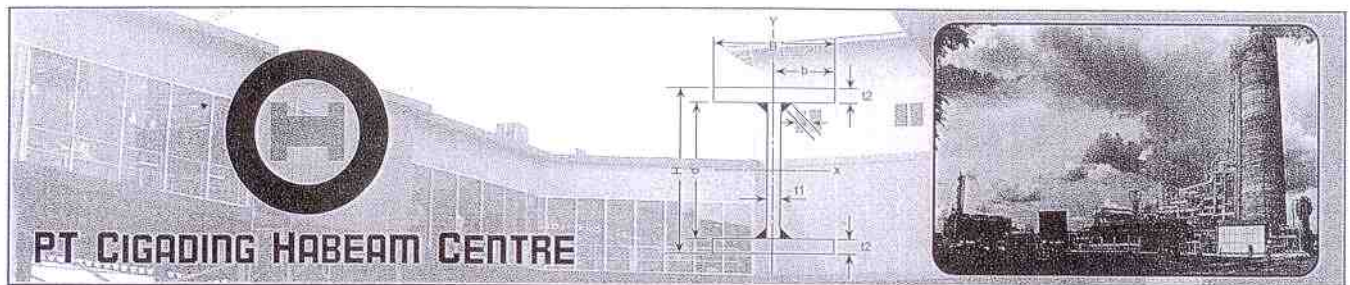
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
750	400	6.0.0	16.0.0	5.0	171.68	134.7	190936.538	17067.959	33.4	9.97	5091.641	853.4
750	400	6.0.0	19.0.0	5.0	195.44	153.2	221150.113	20267.948	33.7	10.19	5897.336	1013.4
750	400	9.0.0	12.0.0	6.3	162.13	127.3	159425.368	12804.410	31.4	8.89	4251.343	640.2
750	400	9.0.0	16.0.0	6.3	193.41	151.8	200190.194	17071.029	32.2	9.39	5338.405	853.6
750	400	9.0.0	19.0.0	6.3	216.87	170.2	230173.716	20270.992	32.6	9.67	6137.966	1013.5
750	400	9.0.0	22.0.0	6.3	240.52	188.7	259656.133	23470.956	32.9	9.88	6924.164	1173.5
750	400	9.0.0	25.0.0	6.3	263.98	207.1	288641.667	26670.919	33.1	10.06	7697.111	1333.5
750	400	12.0.0	16.0.0	8.4	215.57	169.2	209443.850	17077.006	31.2	8.90	5585.169	853.9
750	400	12.0.0	19.0.0	8.4	238.85	187.5	239197.319	20276.919	31.6	9.21	6378.595	1013.8
750	400	12.0.0	22.0.0	8.4	262.13	205.8	268453.528	23476.833	32.0	9.46	7158.761	1173.8
750	400	12.0.0	25.0.0	8.4	285.41	224.0	297216.667	26676.747	32.3	9.67	7925.778	1333.8
750	400	12.0.0	28.0.0	8.4	308.69	242.3	325490.925	29876.660	32.5	9.84	8679.758	1493.8
750	400	12.0.0	32.0.0	8.4	339.73	266.7	362436.699	34143.212	32.7	10.03	9664.979	1707.2
800	200	6.0.0	9.0.0	5.0	83.42	65.5	80224.308	1201.408	31.0	3.79	2005.608	120.1
800	200	6.0.0	12.0.0	5.0	95.06	74.6	97883.469	1601.397	32.1	4.10	2447.087	160.1
800	200	6.0.0	16.0.0	5.0	110.68	86.8	121007.855	2134.716	33.1	4.39	3025.196	213.5
800	200	6.0.0	19.0.0	5.0	122.44	95.9	138037.990	2534.705	33.6	4.55	3450.950	253.5
800	200	9.0.0	12.0.0	6.3	118.63	93.1	109565.683	1604.714	30.4	3.68	2739.142	160.5
800	200	9.0.0	16.0.0	6.3	133.91	105.1	132332.476	2137.999	31.4	4.00	3308.312	213.8
800	200	9.0.0	19.0.0	6.3	145.37	114.1	149099.258	2537.962	32.0	4.18	3727.481	253.8
800	200	9.0.0	22.0.0	6.3	157.02	123.1	165604.065	2937.926	32.5	4.33	4140.102	293.8
800	200	9.0.0	25.0.0	6.3	168.48	132.1	181848.958	3337.890	32.9	4.45	4546.224	333.8
800	200	12.0.0	16.0.0	8.4	157.57	123.7	143657.097	2144.393	30.2	3.69	3591.427	214.4
800	200	12.0.0	19.0.0	8.4	168.85	132.5	160160.526	2544.306	30.8	3.88	4004.013	254.4
800	200	12.0.0	22.0.0	8.4	180.13	141.4	176406.095	2944.220	31.3	4.04	4410.152	294.4
800	200	12.0.0	25.0.0	8.4	191.41	150.3	192395.833	3344.133	31.7	4.18	4809.896	334.4
800	200	12.0.0	28.0.0	8.4	202.69	159.1	208131.772	3744.047	32.0	4.30	5203.294	374.4
800	200	12.0.0	32.0.0	8.4	217.73	170.9	228721.732	4277.265	32.4	4.43	5718.043	427.7
800	200	16.0.0	25.0.0	11.2	222.50	174.7	206458.333	3358.933	30.5	3.89	5161.458	335.9
800	200*	16.0.0	28.0.0	11.2	233.54	183.3	221859.465	3758.729	30.8	4.01	5546.487	375.9
800	200	16.0.0	32.0.0	11.2	248.26	194.9	242011.341	4291.789	31.2	4.16	6050.284	429.2
800	200	16.0.0	38.0.0	11.2	270.34	212.2	271428.083	5091.379	31.7	4.34	6785.702	509.1
800	250	6.0.0	9.0.0	5.0	92.42	72.5	94302.738	2345.158	31.9	5.04	2357.568	187.6
800	250	6.0.0	12.0.0	5.0	107.06	84.0	116513.229	3126.397	33.0	5.40	2912.831	250.1
800	250	6.0.0	16.0.0	5.0	126.68	99.4	145597.508	4168.049	33.9	5.74	3639.938	333.4
800	250	6.0.0	19.0.0	5.0	141.44	110.9	167016.853	4949.288	34.4	5.92	4175.421	395.9
800	250	9.0.0	12.0.0	6.3	130.63	102.5	128195.443	3129.714	31.3	4.89	3204.886	250.4
800	250	9.0.0	16.0.0	6.3	149.91	117.7	156922.129	4171.332	32.4	5.27	3923.053	333.7
800	250	9.0.0	19.0.0	6.3	164.37	129.0	178078.121	4952.546	32.9	5.49	4451.953	396.2



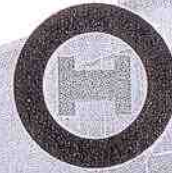
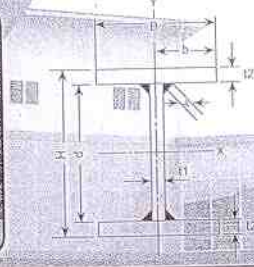
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
800	250	9.0.0	22.0.0	6.3	179.02	140.4	198903.558	5733.759	33.4	5.66	4972.589	458.7
800	250	9.0.0	25.0.0	6.3	193.48	151.7	219401.042	6514.973	33.7	5.81	5485.026	521.2
800	250	12.0.0	16.0.0	8.4	173.57	136.3	168246.750	4177.726	31.1	4.91	4206.169	334.2
800	250	12.0.0	19.0.0	8.4	187.85	147.5	189139.389	4958.889	31.7	5.14	4728.485	396.7
800	250	12.0.0	22.0.0	8.4	202.13	158.7	209705.588	5740.053	32.2	5.33	5242.640	459.2
800	250	12.0.0	25.0.0	8.4	216.41	169.9	229947.917	6521.217	32.6	5.49	5748.698	521.7
800	250	12.0.0	28.0.0	8.4	230.69	181.1	249868.945	7302.380	32.9	5.63	6246.724	584.2
800	250	12.0.0	32.0.0	8.4	249.73	196.0	275934.959	8343.932	33.2	5.78	6898.374	667.5
800	250	16.0.0	25.0.0	11.2	247.50	194.3	244010.417	6536.017	31.4	5.14	6100.260	522.9
800	250	16.0.0	28.0.0	11.2	261.54	205.3	263596.638	7317.062	31.7	5.29	6589.916	585.4
800	250	16.0.0	32.0.0	11.2	280.26	220.0	289224.567	8358.455	32.1	5.46	7230.614	668.7
800	250	16.0.0	38.0.0	11.2	308.34	242.1	326634.990	9920.546	32.5	5.67	8165.875	793.6
800	300	6.0.0	9.0.0	5.0	101.42	79.6	108381.168	4051.408	32.7	6.32	2709.529	270.1
800	300	6.0.0	12.0.0	5.0	119.06	93.5	135142.989	5401.397	33.7	6.74	3378.575	360.1
800	300	6.0.0	16.0.0	5.0	142.68	111.9	170187.162	7201.382	34.5	7.11	4254.679	480.1
800	300	6.0.0	19.0.0	5.0	160.44	125.8	195995.716	8551.372	35.0	7.31	4899.893	570.1
800	300	9.0.0	12.0.0	6.3	142.63	112.0	146825.203	5404.714	32.1	6.16	3670.630	360.3
800	300	9.0.0	16.0.0	6.3	165.91	130.2	181511.782	7204.666	33.1	6.59	4537.795	480.3
800	300	9.0.0	19.0.0	6.3	183.37	143.9	207056.985	8554.629	33.6	6.83	5176.425	570.3
800	300	9.0.0	22.0.0	6.3	201.02	157.7	232203.051	9904.593	34.0	7.02	5805.076	660.3
800	300	9.0.0	25.0.0	6.3	218.48	171.4	256953.125	11254.556	34.3	7.18	6423.828	750.3
800	300	12.0.0	16.0.0	8.4	189.57	148.8	192836.403	7211.059	31.9	6.17	4820.910	480.7
800	300	12.0.0	19.0.0	8.4	206.85	162.4	218118.253	8560.973	32.5	6.43	5452.956	570.7
800	300	12.0.0	22.0.0	8.4	224.13	175.9	243005.082	9910.886	32.9	6.65	6075.127	660.7
800	300	12.0.0	25.0.0	8.4	241.41	189.5	267500.0	11260.80	33.3	6.83	6687.50	750.7
800	300	12.0.0	28.0.0	8.4	258.69	203.1	291606.118	12610.714	33.6	6.98	7290.153	840.7
800	300	12.0.0	32.0.0	8.4	281.73	221.2	323148.186	14410.598	33.9	7.15	8078.705	960.7
800	300	16.0.0	25.0.0	11.2	272.50	213.9	281562.50	11275.60	32.1	6.43	7039.063	751.7
800	300	16.0.0	28.0.0	11.2	289.54	227.3	305333.811	12625.395	32.5	6.60	7633.345	841.7
800	300	16.0.0	32.0.0	11.2	312.26	245.1	336437.794	14425.122	32.8	6.80	8410.945	961.7
800	300	16.0.0	38.0.0	11.2	346.35	271.9	381841.897	17124.713	33.2	7.03	9546.047	1141.6
800	350	6.0.0	9.0.0	5.0	110.42	86.7	122459.598	6432.658	33.3	7.63	3061.490	367.6
800	350	6.0.0	12.0.0	5.0	131.06	102.9	153772.749	8576.397	34.3	8.09	3844.319	490.1
800	350	6.0.0	16.0.0	5.0	158.68	124.5	194776.815	11434.716	35.0	8.49	4869.420	653.4
800	350	6.0.0	19.0.0	5.0	179.44	140.7	224974.580	13578.455	35.4	8.70	5624.364	775.9
800	350	9.0.0	12.0.0	6.3	154.63	121.4	165454.963	8579.714	32.7	7.45	4136.374	490.3
800	350	9.0.0	16.0.0	6.3	181.91	142.8	206101.436	11437.999	33.7	7.93	5152.536	653.6
800	350	9.0.0	19.0.0	6.3	202.37	158.9	236035.848	13581.712	34.2	8.19	5900.896	776.1
800	350	9.0.0	22.0.0	6.3	223.02	174.9	265502.545	15725.426	34.5	8.40	6637.564	898.6



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
800	350	9.0.0	25.0.0	6.3	243.48	191.0	294505.208	17869.140	34.8	8.57	7362.630	1021.1
800	350	12.0.0	16.0.0	8.4	205.57	161.4	217426.057	11444.393	32.5	7.46	5435.651	654.0
800	350	12.0.0	19.0.0	8.4	225.85	177.3	247097.116	13588.056	33.1	7.76	6177.428	776.5
800	350	12.0.0	22.0.0	8.4	246.13	193.2	276304.575	15731.720	33.5	7.99	6907.614	899.0
800	350	12.0.0	25.0.0	8.4	266.41	209.1	305052.083	17875.383	33.8	8.19	7626.302	1021.5
800	350	12.0.0	28.0.0	8.4	286.69	225.1	333343.292	20019.047	34.1	8.36	8333.582	1143.9
800	350	12.0.0	32.0.0	8.4	313.73	246.3	370361.412	22877.265	34.4	8.54	9259.035	1307.3
800	350	16.0.0	25.0.0	11.2	297.50	233.5	319114.583	17890.183	32.8	7.75	7977.865	1022.3
800	350	16.0.0	28.0.0	11.2	317.54	249.3	347070.985	20033.729	33.1	7.94	8676.775	1144.8
800	350	16.0.0	32.0.0	11.2	344.26	270.3	383651.021	22891.789	33.4	8.15	9591.276	1308.1
800	350	16.0.0	38.0.0	11.2	384.34	301.7	437048.803	27178.879	33.7	8.41	10926.220	1553.1
800	400	6.0.0	9.0.0	5.0	119.42	93.7	136538.028	9601.408	33.8	8.97	3413.451	480.1
800	400	6.0.0	12.0.0	5.0	143.06	112.3	172402.509	12801.397	34.7	9.46	4310.063	640.1
800	400	6.0.0	16.0.0	5.0	174.68	137.0	219366.468	17068.049	35.4	9.89	5484.162	853.4
800	400	6.0.0	19.0.0	5.0	198.44	155.6	253953.443	20268.038	35.8	10.11	6348.836	1013.4
800	400	9.0.0	12.0.0	6.3	166.63	130.8	184084.723	12804.714	33.2	8.77	4602.118	640.2
800	400	9.0.0	16.0.0	6.3	197.91	155.4	230691.089	17071.332	34.1	9.29	5767.277	853.6
800	400	9.0.0	19.0.0	6.3	221.37	173.8	265014.711	20271.296	34.6	9.57	6625.368	1013.6
800	400	9.0.0	22.0.0	6.3	245.02	192.2	298802.038	23471.259	34.9	9.79	7470.051	1173.6
800	400	9.0.0	25.0.0	6.3	268.48	210.6	332057.292	26671.223	35.2	9.97	8301.432	1333.6
800	400	12.0.0	16.0.0	8.4	221.57	173.9	242015.710	17077.726	33.0	8.78	6050.393	853.9
800	400	12.0.0	19.0.0	8.4	244.85	192.2	276075.979	20277.639	33.6	9.10	6901.899	1013.9
800	400	12.0.0	22.0.0	8.4	268.13	210.5	309604.068	23477.553	34.0	9.36	7740.102	1173.9
800	400	12.0.0	25.0.0	8.4	291.41	228.8	342604.167	26677.467	34.3	9.57	8565.104	1333.9
800	400	12.0.0	28.0.0	8.4	314.69	247.0	375080.465	29877.380	34.5	9.74	9377.012	1493.9
800	400	12.0.0	32.0.0	8.4	345.73	271.4	417574.639	34143.932	34.8	9.94	10439.366	1707.2
800	400	16.0.0	25.0.0	11.2	322.50	253.2	356666.667	26692.267	33.3	9.10	8916.667	1334.6
800	400	16.0.0	28.0.0	11.2	345.54	271.3	388808.158	29892.062	33.5	9.30	9720.204	1494.6
800	400	16.0.0	32.0.0	11.2	376.26	295.4	430864.247	34158.455	33.8	9.53	10771.606	1707.9
800	400	16.0.0	38.0.0	11.2	422.34	331.5	492255.710	40558.046	34.1	9.80	12306.393	2027.9
800	450	6.0.0	9.0.0	5.0	128.42	100.8	150616.458	13670.158	34.2	10.32	3765.411	607.6
800	450	6.0.0	12.0.0	5.0	155.06	121.7	191032.269	18226.397	35.1	10.84	4775.807	810.1
800	450	6.0.0	16.0.0	5.0	190.68	149.6	243956.122	24301.382	35.8	11.29	6098.903	1080.1
800	450	6.0.0	19.0.0	5.0	217.44	170.5	282932.306	28857.622	36.1	11.53	7073.308	1282.6
800	450	9.0.0	12.0.0	6.3	178.63	140.2	202714.483	18229.714	33.7	10.10	5067.862	810.2
800	450	9.0.0	16.0.0	6.3	213.91	167.9	255280.742	24304.666	34.5	10.66	6382.019	1080.2
800	450	9.0.0	19.0.0	6.3	240.37	188.7	293993.575	28860.879	35.0	10.96	7349.839	1282.7
800	450	9.0.0	22.0.0	6.3	267.02	209.5	332101.531	33417.093	35.3	11.19	8302.538	1485.2
800	450	9.0.0	25.0.0	6.3	293.48	230.2	369609.375	37973.306	35.5	11.38	9240.234	1687.7
800	450	12.0.0	16.0.0	8.4	237.57	186.5	266605.363	24311.059	33.5	10.12	6665.134	1080.5



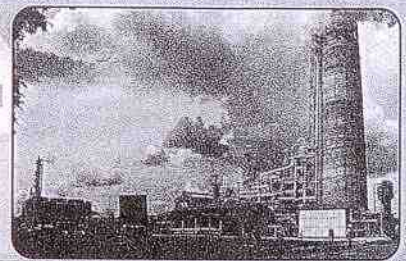
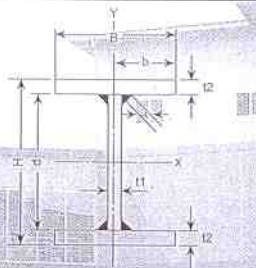
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
800	450	12.0.0	19.0.0	8.4	263.85	207.1	305054.843	28867.223	34.0	10.46	7626.371	1283.0
800	450	12.0.0	22.0.0	8.4	290.13	227.8	342903.562	33423.386	34.4	10.73	8572.589	1485.5
800	450	12.0.0	25.0.0	8.4	316.41	248.4	380156.250	37979.550	34.7	10.96	9503.906	1688.0
800	450	12.0.0	28.0.0	8.4	342.69	269.0	416817.638	42535.714	34.9	11.14	10420.441	1890.5
800	450	12.0.0	32.0.0	8.4	377.73	296.5	464787.866	48610.598	35.1	11.34	11619.697	2160.5
800	450	16.0.0	25.0.0	11.2	347.50	272.8	394218.750	37994.350	33.7	10.46	9855.469	1688.6
800	450	16.0.0	28.0.0	11.2	373.54	293.2	430545.331	42550.395	33.9	10.67	10763.633	1891.1
800	450	16.0.0	32.0.0	11.2	408.26	320.5	478077.474	48625.122	34.2	10.91	11951.937	2161.1
800	450	16.0.0	38.0.0	11.2	460.34	361.4	547462.617	57737.213	34.5	11.20	13686.565	2566.1
850	200	6.0	9.0	5.0	86.42	67.8	92454.238	1201.498	32.7	3.73	2175.394	120.1
850	200	6.0	12.0	5.0	98.06	77.0	112453.039	1601.487	33.9	4.04	2645.954	160.1
850	200	6.0	16.0	5.0	113.68	89.2	138669.785	2134.806	34.9	4.34	3262.818	213.5
850	200	6.0	19.0	5.0	125.44	98.3	157998.820	2534.795	35.5	4.50	3717.619	253.5
850	200	9.0	12.0	6.3	123.13	96.7	126542.038	1605.018	32.1	3.61	2977.460	160.5
850	200	9.0	16.0	6.3	138.41	108.7	152353.371	2138.303	33.2	3.93	3584.785	213.8
850	200	9.0	19.0	6.3	149.87	117.7	171383.503	2538.266	33.8	4.12	4032.553	253.8
850	200	9.0	22.0	6.3	161.52	126.6	190134.470	2938.230	34.3	4.27	4473.752	293.8
850	200	9.0	25.0	6.3	172.98	135.6	208608.333	3338.193	34.7	4.40	4908.431	333.8
850	200	12.0	16.0	8.4	163.57	128.4	166036.957	2145.113	31.9	3.62	3906.752	214.5
850	200	12.0	19.0	8.4	174.85	137.3	184768.186	2545.026	32.5	3.82	4347.487	254.5
850	200	12.0	22.0	8.4	186.13	146.1	203224.635	2944.940	33.0	3.98	4781.756	294.5
850	200	12.0	25.0	8.4	197.41	155.0	221408.333	3344.853	33.5	4.12	5209.608	334.5
850	200	12.0	28.0	8.4	208.69	163.8	239321.312	3744.767	33.9	4.24	5631.090	374.5
850	200	12.0	32.0	8.4	223.73	175.6	262787.672	4277.985	34.3	4.37	6183.239	427.8
850	200	16.0	25.0	11.2	230.50	180.9	238475.000	3360.640	32.2	3.82	5611.176	336.1
850	200	16.0	28.0	11.2	241.54	189.6	256006.851	3760.435	32.6	3.95	6023.691	376.0
850	200	16.0	32.0	11.2	256.26	201.2	278973.927	4293.495	33.0	4.09	6564.092	429.3
850	200	16.0	38.0	11.2	278.34	218.5	312558.270	5093.086	33.5	4.28	7354.312	509.3
850	250	6.0	9.0	5.0	95.42	74.9	108368.668	2345.248	33.7	4.96	2549.851	187.6
850	250	6.0	12.0	5.0	110.06	86.4	133521.799	3126.487	34.8	5.33	3141.689	250.1
850	250	6.0	16.0	5.0	129.68	101.7	166495.438	4168.139	35.8	5.67	3917.540	333.5
850	250	6.0	19.0	5.0	144.44	113.21	190806.183	4949.378	36.4	5.86	4489.557	396.0
850	250	9.0	12.0	6.3	135.13	106.1	147610.798	3130.018	33.1	4.81	3473.195	250.4
850	250	9.0	16.0	6.3	154.41	121.2	180179.024	4171.636	34.2	5.20	4239.506	333.7
850	250	9.0	19.0	6.3	168.87	132.6	204190.866	4952.850	34.8	5.42	4804.491	396.2
850	250	9.0	22.0	6.3	183.52	143.9	227850.463	5734.063	35.3	5.59	5361.187	458.7
850	250	9.0	25.0	6.3	197.98	155.3	251160.417	6515.277	35.6	5.74	5909.657	521.2
850	250	12.0	16.0	8.4	179.57	141.0	193862.610	4178.446	32.9	4.82	4561.473	334.3

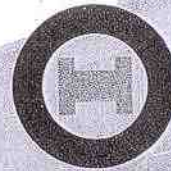
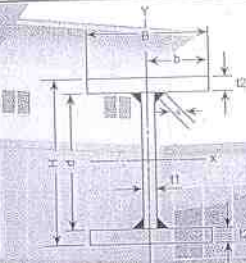


PT CIGADING HBEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

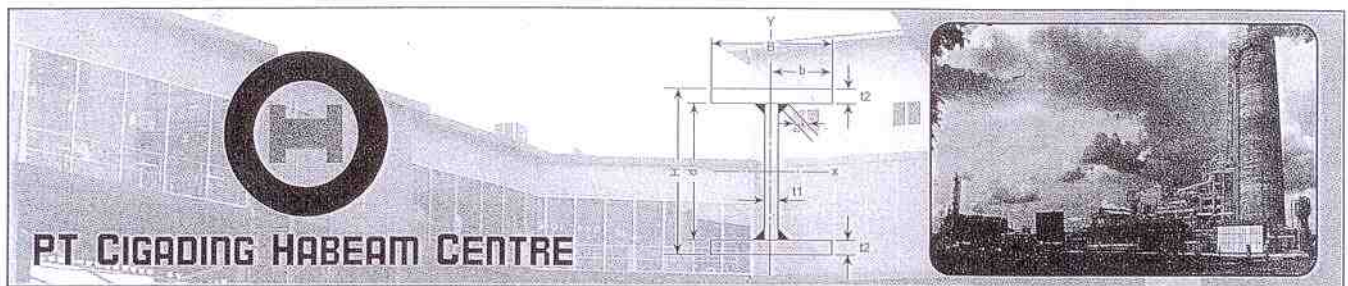
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
850	250	12.0	19.0	8.4	193.85	152.2	217575.549	4959.609	33.5	5.06	5119.425	396.8
850	250	12.0	22.0	8.4	208.13	163.4	240940.628	5740.773	34.0	5.25	5669.191	459.3
850	250	12.0	25.0	8.4	222.41	174.6	263960.417	6521.937	34.5	5.42	6210.833	521.8
850	250	12.0	28.0	8.4	236.69	185.8	286637.485	7303.10	34.8	5.55	6744.411	584.2
850	250	12.0	32.0	8.4	255.73	200.7	316344.899	8344.652	35.2	5.71	7443.409	667.6
850	250	16.0	25.0	11.2	255.50	200.6	281027.083	6537.723	33.2	5.06	6612.402	523.0
850	250	16.0	28.0	11.2	269.54	211.6	303323.025	7318.769	33.5	5.21	7137.012	585.5
850	250	16.0	32.0	11.2	288.26	226.3	332531.154	8360.162	34.0	5.39	7824.262	668.8
850	250	16.0	38.0	11.2	316.34	248.3	375241.677	9922.253	34.4	5.60	8829.216	793.8
850	300	6.0	9.0	5.0	104.42	82.0	124283.098	4051.498	34.5	6.23	2924.308	270.1
850	300	6.0	12.0	5.0	122.06	95.8	154590.559	5401.487	35.6	6.65	3637.425	360.1
850	300	6.0	16.0	5.0	145.68	114.3	194321.092	7201.472	36.5	7.03	4572.261	480.1
850	300	6.0	19.0	5.0	163.44	128.1	223613.546	8551.462	37.0	7.24	5261.495	570.1
850	300	9.0	12.0	6.3	147.13	115.5	168679.558	5405.018	33.9	6.06	3968.931	360.3
850	300	9.0	16.0	6.3	170.41	133.8	208004.677	7204.969	34.9	6.50	4894.228	480.3
850	300	9.0	19.0	6.3	187.87	147.5	236998.230	8554.933	35.5	6.75	5576.429	570.3
850	300	9.0	22.0	6.3	205.52	161.2	265566.456	9904.896	36.0	6.95	6248.622	660.3
850	300	9.0	25.0	6.3	222.98	174.9	293712.50	11254.860	36.3	7.11	6910.882	750.3
850	300	12.0	16.0	8.4	195.57	153.5	221688.263	7211.779	33.7	6.07	5216.194	480.8
850	300	12.0	19.0	8.4	212.85	167.1	250382.913	8561.693	34.3	6.34	5891.363	570.8
850	300	12.0	22.0	8.4	230.13	180.7	278656.622	9911.606	34.8	6.56	6556.626	660.8
850	300	12.0	25.0	8.4	247.41	194.2	306512.50	11261.520	35.2	6.75	7212.059	750.8
850	300	12.0	28.0	8.4	264.69	207.8	333953.658	12611.434	35.5	6.90	7857.733	840.8
850	300	12.0	32.0	8.4	287.73	225.9	369902.126	14411.318	35.9	7.08	8703.579	960.8
850	300	16.0	25.0	11.2	280.50	220.2	323579.167	11277.307	34.0	6.34	7613.627	751.8
850	300	16.0	28.0	11.2	297.54	233.6	350639.198	12627.102	34.3	6.51	8250.334	841.8
850	300	16.0	32.0	11.2	320.26	251.4	386088.381	14426.829	34.7	6.71	9084.432	961.8
850	300	16.0	38.0	11.2	354.34	278.2	437925.083	17126.419	35.2	6.95	10304.120	1141.8
850	350	6.0.0	9.0.0	5.0	113.42	89.0	140197.528	6432.748	35.2	7.53	3298.765	367.6
850	350	6.0.0	12.0.0	5.0	134.06	105.2	175659.319	8576.487	36.2	8.00	4133.160	490.1
850	350	6.0.0	16.0.0	5.0	161.68	126.8	222146.745	11434.806	37.1	8.41	5226.982	653.4
850	350	6.0.0	19.0.0	5.0	182.44	143.0	256420.910	13578.545	37.5	8.63	6033.433	775.9
850	350	9.0.0	12.0.0	6.3	159.13	124.9	189748.318	8580.018	34.5	7.34	4464.666	490.3
850	350	9.0.0	16.0.0	6.3	186.41	146.3	235830.331	11438.303	35.6	7.83	5548.949	653.6
850	350	9.0.0	19.0.0	6.3	206.87	162.4	269805.593	13582.016	36.1	8.10	6348.367	776.1
850	350	9.0.0	22.0.0	6.3	227.52	178.5	303282.450	15725.730	36.5	8.32	7136.058	898.6
850	350	9.0.0	25.0.0	6.3	247.98	194.5	336264.583	17869.443	36.8	8.49	7912.108	1021.1
850	350	12.0.0	16.0.0	8.4	211.57	166.1	249513.917	11445.113	34.3	7.35	5870.916	654.0



PT CIGADING HABEAM CENTRE

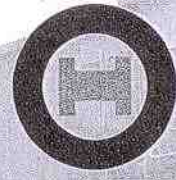
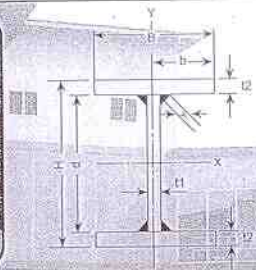
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
850	350	12.0.0	19.0.0	8.4	231.85	182.0	283190.276	13588.776	34.9	7.66	6663.301	776.5
850	350	12.0.0	22.0.0	8.4	252.13	197.9	316372.615	15732.440	35.4	7.90	7444.062	899.0
850	350	12.0.0	25.0.0	8.4	272.41	213.8	349064.583	17876.103	35.8	8.10	8213.284	1021.5
850	350	12.0.0	28.0.0	8.4	292.69	229.8	381269.832	20019.767	36.1	8.27	8971.055	1144.0
850	350	12.0.0	32.0.0	8.4	319.73	251.0	423459.352	22877.985	36.4	8.46	9963.749	1307.3
850	350	16.0.0	25.0.0	11.2	305.50	239.8	366131.250	17891.890	34.6	7.65	8614.853	1022.4
850	350	16.0.0	28.0.0	11.2	325.54	255.6	397955.371	20035.435	35.0	7.84	9363.656	1144.9
850	350	16.0.0	32.0.0	11.2	352.26	276.5	439645.607	22893.495	35.3	8.06	10344.603	1308.2
850	350	16.0.0	38.0.0	11.2	392.34	308.0	500608.490	27180.586	35.7	8.32	11779.023	1553.2
850	400	6.0.0	9.0.0	5.0	122.42	96.1	156111.958	9601.498	35.7	8.86	3673.223	480.1
850	400	6.0.0	12.0.0	5.0	146.06	114.7	196728.079	12801.487	36.7	9.36	4628.896	640.1
850	400	6.0.0	16.0.0	5.0	177.68	139.4	249972.398	17068.139	37.5	9.80	5881.703	853.4
850	400	6.0.0	19.0.0	5.0	201.51	158.0	289228.273	20268.128	37.9	10.04	6805.371	1013.4
850	400	9.0.0	12.0.0	6.3	171.13	134.3	210817.078	12805.018	35.1	8.65	4960.402	640.3
850	400	9.0.0	16.0.0	6.3	202.41	158.9	263655.984	17071.636	36.1	9.18	6203.670	853.6
850	400	9.0.0	19.0.0	6.3	225.87	177.3	302612.956	20271.60	36.6	9.47	7120.305	1013.6
850	400	9.0.0	22.0.0	6.3	249.52	195.7	340998.443	23471.563	37.0	9.70	8023.493	1173.6
850	400	9.0.0	25.0.0	6.3	272.98	214.1	378816.667	26671.527	37.3	9.89	8913.333	1333.6
850	400	12.0.0	16.0.0	8.4	227.57	178.6	277339.570	17078.446	34.9	8.66	6525.637	853.9
850	400	12.0.0	19.0.0	8.4	250.85	196.9	315997.639	20278.359	35.5	8.99	7435.239	1013.9
850	400	12.0.0	22.0.0	8.4	274.13	215.2	354088.608	23478.273	35.9	9.25	8331.497	1173.9
850	400	12.0.0	25.0.0	8.4	297.41	233.5	391616.667	26678.187	36.3	9.47	9214.510	1333.9
850	400	12.0.0	28.0.0	8.4	320.69	251.7	428586.005	29878.10	36.6	9.65	10084.377	1493.9
850	400	12.0.0	32.0.0	8.4	351.73	276.1	477016.579	34144.652	36.8	9.85	11223.920	1707.2
850	400	16.0.0	25.0.0	11.2	330.50	259.4	408683.333	26693.973	35.2	8.99	9616.078	1334.7
850	400	16.0.0	28.0.0	11.2	353.54	277.5	445271.545	29893.769	35.5	9.20	10476.978	1494.7
850	400	16.0.0	32.0.0	11.2	384.26	301.7	493202.834	34160.162	35.8	9.43	11604.773	1708.0
850	400	16.0.0	36.0.0	11.2	414.98	325.8	540168.287	38426.556	36.1	9.62	12709.842	1921.3
850	400	16.0.0	38.0.0	11.2	430.34	337.8	563291.897	40559.753	36.2	9.71	13253.927	2028.0
850	450	6.0.0	9.0.0	5.0	131.42	103.2	172026.388	13670.248	36.2	10.20	4047.680	607.6
850	450	6.0.0	12.0.0	5.0	158.06	124.1	217796.839	18226.487	37.1	10.74	5124.632	810.1
850	450	6.0.0	16.0.0	5.0	193.68	152.0	277798.052	24301.472	37.9	11.20	6536.425	1080.1
850	450	6.0.0	19.0.0	5.0	220.44	172.9	322035.636	28857.712	38.2	11.45	7577.309	1282.6
850	450	9.0.0	12.0.0	6.3	183.13	143.8	231885.838	18230.018	35.6	9.98	5456.137	810.2
850	450	9.0.0	16.0.0	6.3	218.41	171.5	291481.637	24304.969	36.5	10.55	6858.391	1080.2
850	450	9.0.0	19.0.0	6.3	244.87	192.2	335420.320	28861.183	37.0	10.86	7892.243	1282.7
850	450	9.0.0	22.0.0	6.3	271.52	213.0	378714.436	33417.396	37.4	11.10	8910.928	1485.2
850	450	9.0.0	25.0.0	6.3	297.98	233.8	421368.750	37973.610	37.6	11.29	9914.559	1687.7



UKURAN DAN SIFAT-SIFAT PENAMPANG

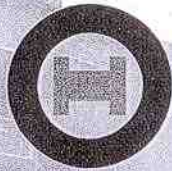
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
850	450	12.0.0	16.0.0	8.4	243.57	191.2	305165.223	24311.779	35.4	9.99	7180.358	1080.5
850	450	12.0.0	19.0.0	8.4	269.85	211.8	348805.003	28867.943	36.0	10.34	8207.177	1283.0
850	450	12.0.0	22.0.0	8.4	296.13	232.5	391804.602	33424.106	36.4	10.62	9218.932	1485.5
850	450	12.0.0	25.0.0	8.4	322.41	253.1	434168.750	37980.270	36.7	10.85	10215.735	1688.0
850	450	12.0.0	28.0.0	8.4	348.69	273.7	475902.178	42536.434	36.9	11.04	11197.698	1890.5
850	450	12.0.0	32.0.0	8.4	383.73	301.2	530573.806	48611.318	37.2	11.26	12484.090	2160.5
850	450	16.0.0	25.0.0	11.2	355.50	279.1	451235.417	37996.057	35.6	10.34	10617.304	1688.7
850	450	16.0.0	28.0.0	11.2	381.54	299.5	492587.718	42552.102	35.9	10.56	11590.299	1891.2
850	450	16.0.0	32.0.0	11.2	416.26	326.8	546760.061	48626.829	36.2	10.81	12864.943	2161.2
850	450	16.0.0	36.0.0	11.2	450.98	354.0	599840.807	54701.556	36.5	11.01	14113.901	2431.2
850	450	16.0.0	38.0.0	11.2	468.34	367.7	625975.303	57738.919	36.6	11.10	14728.831	2566.2
900	200	6.0.0	9.0.0	5.0	89.42	70.2	105758.168	1201.588	34.4	3.67	2350.182	120.2
900	200	6.0.0	12.0.0	5.0	101.06	79.3	128242.109	1601.577	35.6	3.98	2849.825	160.2
900	200	6.0.0	16.0.0	5.0	116.68	91.5	157745.215	2134.896	36.8	4.28	3505.449	213.5
900	200	6.0.0	19.0.0	5.0	128.44	100.7	179518.650	2534.885	37.4	4.45	3989.303	253.5
900	200	9.0.0	12.0.0	6.3	127.63	100.2	145047.643	1605.322	33.7	3.55	3223.281	160.5
900	200	9.0.0	16.0.0	6.3	142.91	112.2	174094.516	2138.606	34.9	3.87	3868.767	213.9
900	200	9.0.0	19.0.0	6.3	154.37	121.2	195531.248	2538.570	35.6	4.06	4345.139	253.9
900	200	9.0.0	22.0.0	6.3	166.02	130.2	216671.625	2938.534	36.1	4.21	4814.925	293.9
900	200	9.0.0	25.0.0	6.3	177.48	139.2	237517.708	3338.497	36.6	4.34	5278.171	333.8
900	200	12.0.0	16.0.0	8.4	169.57	133.1	190443.817	2145.833	33.5	3.56	4232.085	214.6
900	200	12.0.0	19.0.0	8.4	180.85	142.0	211543.846	2545.746	34.2	3.75	4700.974	254.6
900	200	12.0.0	22.0.0	8.4	192.13	150.8	232352.175	2945.660	34.8	3.92	5163.382	294.6
900	200	12.0.0	25.0.0	8.4	203.41	159.7	252870.833	3345.573	35.3	4.06	5619.352	334.6
900	200	12.0.0	28.0.0	8.4	214.69	168.5	273101.852	3745.487	35.7	4.18	6068.930	374.5
900	200	12.0.0	32.0.0	8.4	229.73	180.3	299632.612	4278.705	36.1	4.32	6658.502	427.9
900	200	16.0.0	25.0.0	11.2	238.50	187.2	273341.667	3362.347	33.9	3.75	6074.259	336.2
900	200	16.0.0	28.0.0	11.2	249.54	195.9	293142.238	3762.142	34.3	3.88	6514.272	376.2
900	200	16.0.0	32.0.0	11.2	264.26	207.5	319108.514	4295.202	34.7	4.03	7091.30	429.5
900	200	16.0.0	36.0.0	11.2	278.98	219.0	344582.554	4828.262	35.1	4.16	7657.390	482.8
900	200	16.0.0	38.0.0	11.2	236.34	224.8	357136.457	5094.793	35.3	4.22	7936.366	509.5
900	250	6.0.0	9.0.0	5.0	98.42	77.3	123621.098	2345.338	35.4	4.88	2747.136	187.6
900	250	6.0.0	12.0.0	5.0	113.06	88.8	151899.869	3126.577	36.7	5.26	3375.553	250.1
900	250	6.0.0	16.0.0	5.0	132.68	104.1	189006.868	4168.229	37.8	5.61	4200.153	333.5
900	250	6.0.0	19.0.0	5.0	147.44	115.6	216392.013	4949.468	38.3	5.80	4808.711	396.0
900	250	9.0.0	12.0.0	6.3	139.63	109.6	168705.403	3130.322	34.8	4.73	3749.009	250.4
900	250	9.0.0	16.0.0	6.3	158.91	124.7	205356.169	4171.940	35.9	5.12	4563.470	333.8
900	250	9.0.0	19.0.0	6.3	173.37	136.1	232404.611	4953.153	36.6	5.35	5164.547	396.3



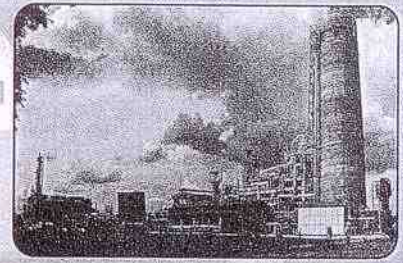
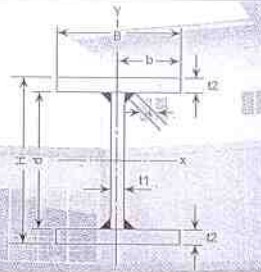
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
900	250	9.0.0	22.0.0	6.3	188.02	147.4	259079.118	5734.367	37.1	5.53	5757.314	458.7
900	250	9.0.0	25.0.0	6.3	202.48	158.8	285382.292	6515.580	37.6	5.68	6341.829	521.2
900	250	12.0.0	16.0.0	8.4	185.57	145.7	221705.470	4179.166	34.6	4.75	4926.788	334.3
900	250	12.0.0	19.0.0	8.4	199.85	156.9	248417.209	4960.329	35.3	4.98	5520.382	396.8
900	250	12.0.0	22.0.0	8.4	214.13	168.1	274759.668	5741.493	35.8	5.18	6105.770	459.3
900	250	12.0.0	25.0.0	8.4	228.41	179.3	300735.417	6522.657	36.3	5.34	6683.009	521.8
900	250	12.0.0	28.0.0	8.4	242.69	190.5	326347.025	7303.820	36.7	5.49	7252.156	584.3
900	250	12.0.0	32.0.0	8.4	261.73	205.5	359933.839	8345.372	37.1	5.65	7998.530	667.6
900	250	16.0.0	25.0.0	11.2	263.50	206.9	321206.250	6539.430	34.9	4.98	7137.917	523.2
900	250	16.0.0	28.0.0	11.2	277.54	217.9	346387.411	7320.475	35.3	5.14	7697.498	585.6
900	250	16.0.0	32.0.0	11.2	296.26	232.6	379409.741	8361.869	35.8	5.31	8431.328	668.9
900	250	16.0.0	36.0.0	11.2	314.98	247.3	411806.074	9403.262	36.2	5.46	9151.246	752.3
900	250	16.0.0	38.0.0	11.2	324.34	254.6	427771.363	9923.959	36.3	5.53	9506.030	793.9
900	300	6.0.0	9.0.0	5.0	107.42	84.3	141484.028	4051.588	36.3	6.14	3144.090	270.1
900	300	6.0.0	12.0.0	5.0	125.06	98.2	175557.629	5401.577	37.5	6.57	3901.281	360.1
900	300	6.0.0	16.0.0	5.0	148.68	116.6	220268.522	7201.562	38.5	6.96	4894.856	480.1
900	300	6.0.0	19.0.0	5.0	166.44	130.5	253265.376	8551.552	39.0	7.17	5628.119	570.1
900	300	9.0.0	12.0.0	6.3	151.63	119.0	192363.163	5405.322	35.6	5.97	4274.737	360.4
900	300	9.0.0	16.0.0	6.3	174.91	137.3	236617.822	7205.273	36.8	6.42	5258.174	480.4
900	300	9.0.0	19.0.0	6.3	192.37	151.0	269277.975	8555.237	37.4	6.67	5983.955	570.3
900	300	9.0.0	22.0.0	6.3	210.02	164.7	301486.611	9905.20	37.9	6.87	6699.702	660.3
900	300	9.0.0	25.0.0	6.3	227.48	178.4	333246.875	11255.164	38.3	7.04	7405.486	750.3
900	300	12.0.0	16.0.0	8.4	201.57	158.2	252967.123	7212.499	35.4	5.98	5621.492	480.8
900	300	12.0.0	19.0.0	8.4	218.85	171.8	285290.573	8562.413	36.1	6.25	6339.791	570.8
900	300	12.0.0	22.0.0	8.4	236.13	185.4	317167.162	9912.326	36.6	6.48	7048.159	660.8
900	300	12.0.0	25.0.0	8.4	253.41	198.9	348600.0	11262.240	37.1	6.67	7746.667	750.8
900	300	12.0.0	28.0.0	8.4	270.69	212.5	379592.198	12612.154	37.4	6.83	8435.382	840.8
900	300	12.0.0	32.0.0	8.4	293.73	230.6	420235.066	14412.038	37.8	7.00	9338.557	960.8
900	300	16.0.0	25.0.0	11.2	288.50	226.5	369070.833	11279.013	35.8	6.25	8201.574	751.9
900	300	16.0.0	28.0.0	11.2	305.54	239.9	399632.585	12628.809	36.2	6.43	8880.724	841.9
900	300	16.0.0	32.0.0	11.2	328.26	257.7	439710.967	14428.535	36.6	6.63	9771.355	961.9
900	300	16.0.0	36.0.0	11.2	350.98	275.5	479029.594	16228.262	36.9	6.80	10645.102	1081.9
900	300	16.0.0	38.0.0	11.2	362.34	284.4	498406.270	17128.126	37.1	6.88	11075.695	1141.9
900	350	6.0.0	9.0.0	5.0	116.42	91.4	159346.958	6432.838	37.0	7.43	3541.044	367.6
900	350	6.0.0	12.0.0	5.0	137.06	107.6	199215.389	8576.577	38.1	7.91	4427.009	490.1
900	350	6.0.0	16.0.0	5.0	164.68	129.2	251530.175	11434.896	39.1	8.34	5589.559	653.4
900	350	6.0.0	19.0.0	5.0	185.44	145.4	290138.740	13578.635	39.6	8.56	6447.528	775.9
900	350	9.0.0	12.0.0	6.3	163.63	128.5	216020.923	8580.322	36.3	7.24	4800.465	490.3

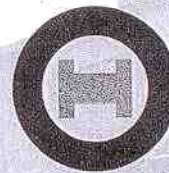
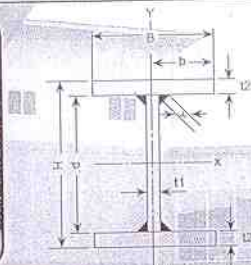


PT CIGADING HAKEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

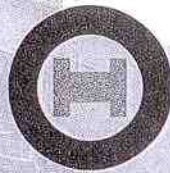
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
900	350	9.0.0	16.0.0	6.3	190.91	149.9	267879.476	11438.606	37.5	7.74	5952.877	653.6
900	350	9.0.0	19.0.0	6.3	211.37	165.9	306151.338	13582.320	38.1	8.02	6803.363	776.1
900	350	9.0.0	22.0.0	6.3	232.02	182.0	343894.105	15726.034	38.5	8.24	7642.091	898.6
900	350	9.0.0	25.0.0	6.3	252.48	198.1	381111.458	17869.747	38.9	8.42	8469.144	1021.1
900	350	12.0.0	16.0.0	8.4	217.57	170.8	284228.777	11445.833	36.1	7.25	6316.195	654.0
900	350	12.0.0	19.0.0	8.4	237.85	186.7	322163.936	13589.496	36.8	7.56	7159.199	776.5
900	350	12.0.0	22.0.0	8.4	258.13	202.6	359574.655	15733.160	37.3	7.81	7990.548	899.0
900	350	12.0.0	25.0.0	8.4	278.41	218.6	396464.583	17876.823	37.7	8.01	8810.324	1021.5
900	350	12.0.0	28.0.0	8.4	298.69	234.5	432837.372	20020.487	38.1	8.19	9618.608	1144.0
900	350	12.0.0	32.0.0	8.4	325.73	255.7	480536.292	22878.705	38.4	8.38	10678.584	1307.4
900	350	16.0.0	25.0.0	11.2	313.50	246.1	416935.417	17893.597	36.5	7.55	9265.231	1022.5
900	350	16.0.0	28.0.0	11.2	333.54	261.8	452877.758	20037.142	36.8	7.75	10063.950	1145.0
900	350	16.0.0	32.0.0	11.2	360.26	282.8	500012.194	22895.202	37.3	7.97	11111.382	1308.3
900	350	16.0.0	36.0.0	11.2	386.98	303.8	546253.114	25753.262	37.6	8.16	12138.958	1471.6
900	350	16.0.0	38.0.0	11.2	400.34	314.3	569041.177	27182.293	37.7	8.24	12645.359	1553.3
900	400	6.0.0	9.0.0	5.0	125.42	98.5	177209.888	9601.588	37.6	8.75	3937.998	480.1
900	400	6.0.0	12.0.0	5.0	149.06	117.0	222873.149	12801.577	38.7	9.27	4952.737	640.1
900	400	6.0.0	16.0.0	5.0	180.58	141.8	282791.828	17068.229	39.6	9.72	6284.263	853.4
900	400	6.0.0	19.0.0	5.0	204.44	160.3	327012.103	20268.218	40.0	9.96	7266.936	1013.4
900	400	9.0.0	12.0.0	6.3	175.63	137.9	239678.683	12805.322	36.9	8.54	5326.193	640.3
900	400	9.0.0	16.0.0	6.3	206.91	162.4	299141.129	17071.940	38.0	9.08	6647.581	853.6
900	400	9.0.0	19.0.0	6.3	230.37	180.8	343024.701	20271.903	38.6	9.38	7622.771	1013.6
900	400	9.0.0	22.0.0	6.3	254.02	199.3	386301.598	23471.867	39.0	9.62	8584.480	1173.6
900	400	9.0.0	25.0.0	6.3	277.48	217.7	428976.042	26671.830	39.3	9.81	9532.801	1333.6
900	400	12.0.0	16.0.0	8.4	233.57	183.4	315490.430	17079.166	36.8	8.55	7010.898	854.0
900	400	12.0.0	19.0.0	8.4	256.85	201.6	359037.299	20279.079	37.4	8.89	7978.607	1014.0
900	400	12.0.0	22.0.0	8.4	280.13	219.9	401982.148	23478.993	37.9	9.16	8932.937	1173.9
900	400	12.0.0	25.0.0	8.4	303.41	238.2	444329.167	26678.907	38.3	9.38	9873.981	1333.9
900	400	12.0.0	28.0.0	8.4	326.69	256.5	486082.545	29878.820	38.6	9.56	10801.834	1493.9
900	400	12.0.0	32.0.0	8.4	357.73	280.8	540837.519	34145.372	38.9	9.77	12018.612	1707.3
900	400	16.0.0	25.0.0	11.2	338.50	265.7	464800.0	26695.680	37.1	8.88	10328.889	1334.8
900	400	16.0.0	28.0.0	11.2	361.54	283.8	506122.931	29895.475	37.4	9.09	11247.176	1494.8
900	400	16.0.0	32.0.0	11.2	392.26	307.9	560313.421	34161.869	37.8	9.33	12451.409	1708.1
900	400	16.0.0	36.0.0	11.2	422.98	332.0	613476.634	38428.262	38.1	9.53	13632.814	1921.4
900	400	16.0.0	38.0.0	11.2	438.34	344.1	639676.083	40561.459	38.2	9.62	14215.024	2028.1
900	450	6.0.0	9.0.0	5.0	134.42	105.5	195072.818	13670.338	38.1	10.08	4334.952	607.6
900	450	6.0.0	12.0.0	5.0	161.06	126.4	246530.909	18226.577	39.1	10.64	5478.465	810.1
900	450	6.0.0	16.0.0	5.0	196.68	154.3	314053.482	24301.562	40.0	11.12	6978.966	1080.1



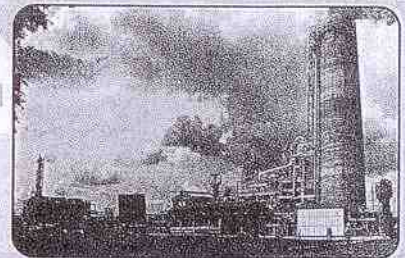
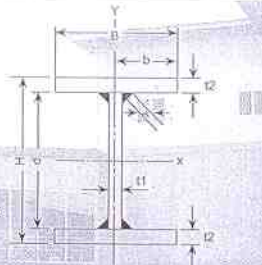
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
900	450	6.0.0	19.0.0	5.0	223.44	175.2	363885.466	28857.802	40.4	11.37	8086.344	1282.6
900	450	9.0.0	12.0.0	6.3	187.63	147.3	263336.443	18230.322	37.5	9.86	5851.921	810.2
900	450	9.0.0	16.0.0	6.3	222.91	175.0	330402.782	24305.273	38.5	10.44	7342.284	1080.2
900	450	9.0.0	19.0.0	6.3	249.37	195.8	379898.065	28861.487	39.0	10.76	8442.179	1282.7
900	450	9.0.0	22.0.0	6.3	276.02	216.5	428709.091	33417.70	39.4	11.01	9526.869	1485.2
900	450	9.0.0	25.0.0	6.3	302.48	237.3	476840.625	37973.914	39.7	11.21	10596.458	1687.7
900	450	12.0.0	16.0.0	8.4	249.57	195.9	346752.083	24312.499	37.3	9.87	7705.602	1080.6
900	450	12.0.0	19.0.0	8.4	275.85	216.5	395910.663	28868.663	37.9	10.23	8798.015	1283.1
900	450	12.0.0	22.0.0	8.4	302.13	237.2	444389.642	33424.826	38.4	10.52	9875.325	1485.5
900	450	12.0.0	25.0.0	8.4	328.41	257.8	492193.750	37980.990	38.7	10.75	10937.639	1688.0
900	450	12.0.0	28.0.0	8.4	354.69	278.4	539327.718	42537.154	39.0	10.95	11985.060	1890.5
900	450	12.0.0	32.0.0	8.4	389.73	305.9	601138.746	48612.038	39.3	11.17	13358.639	2160.5
900	450	16.0.0	25.0.0	11.2	363.50	285.4	512664.583	37997.763	37.6	10.22	11392.546	1688.8
900	450	16.0.0	28.0.0	11.2	389.54	305.8	559368.105	42553.809	37.9	10.45	12430.402	1891.3
900	450	16.0.0	32.0.0	11.2	424.26	333.1	620614.647	48628.535	38.2	10.71	13791.437	2161.3
900	450	16.0.0	36.0.0	11.2	458.98	360.3	680700.154	54703.262	38.5	10.92	15126.670	2431.3
900	450	16.0.0	38.0.0	11.2	476.34	373.9	710310.990	57740.626	38.6	11.01	15784.689	2566.3
950	200	6.0.0	9.0.0	5.0	92.42	72.5	120173.598	1201.678	36.1	3.61	2529.970	120.2
950	200	6.0.0	12.0.0	5.0	104.06	81.7	145288.179	1601.667	37.4	3.92	3058.699	160.2
950	200	6.0.0	16.0.0	5.0	119.68	93.9	178271.645	2134.986	38.6	4.23	3753.087	213.5
950	200	6.0.0	19.0.0	5.0	131.44	103.0	202634.980	2534.975	39.3	4.40	4266.0	253.5
950	200	9.0.0	12.0.0	6.3	132.13	103.7	165138.748	1605.625	35.4	3.49	3476.605	160.6
950	200	9.0.0	16.0.0	6.3	147.41	115.7	197612.161	2138.910	36.6	3.81	4160.256	213.9
950	200	9.0.0	19.0.0	6.3	158.87	124.7	221598.743	2538.874	37.3	4.00	4665.237	253.9
950	200	9.0.0	22.0.0	6.3	170.52	133.7	245271.780	2938.837	37.9	4.15	5163.616	293.9
950	200	9.0.0	25.0.0	6.3	181.98	142.7	268633.333	3338.801	38.4	4.29	5655.439	333.9
950	200	12.0.0	16.0.0	8.4	175.57	137.8	216952.677	2146.553	35.2	3.50	4567.425	214.7
950	200	12.0.0	19.0.0	8.4	186.85	146.7	240562.506	2546.466	35.9	3.69	5064.474	254.6
950	200	12.0.0	22.0.0	8.4	198.13	155.5	263863.715	2946.380	36.5	3.86	5555.026	294.6
950	200	12.0.0	25.0.0	8.4	209.41	164.4	286858.333	3346.293	37.0	4.00	6039.123	334.6
950	200	12.0.0	28.0.0	8.4	220.69	173.2	309548.392	3746.207	37.5	4.12	6516.808	374.6
950	200	12.0.0	32.0.0	8.4	235.73	185.0	339331.552	4279.425	37.9	4.26	7143.822	427.9
950	200	16.0.0	25.0.0	11.2	246.50	193.5	311158.333	3364.053	35.5	3.69	6550.702	336.4
950	200	16.0.0	28.0.0	11.2	257.54	202.2	333365.625	3763.849	36.0	3.82	7018.224	376.4
950	200	16.0.0	32.0.0	11.2	272.26	213.7	362515.101	4296.909	36.5	3.97	7631.897	429.7
950	200	16.0.0	36.0.0	11.2	286.98	225.3	391142.90	4829.969	36.9	4.10	8234.587	483.0
950	200	16.0.0	38.0.0	11.2	294.34	231.1	405262.643	5096.499	37.1	4.16	8531.845	509.6

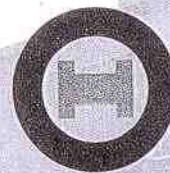
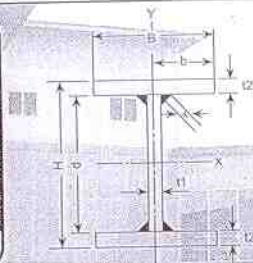


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

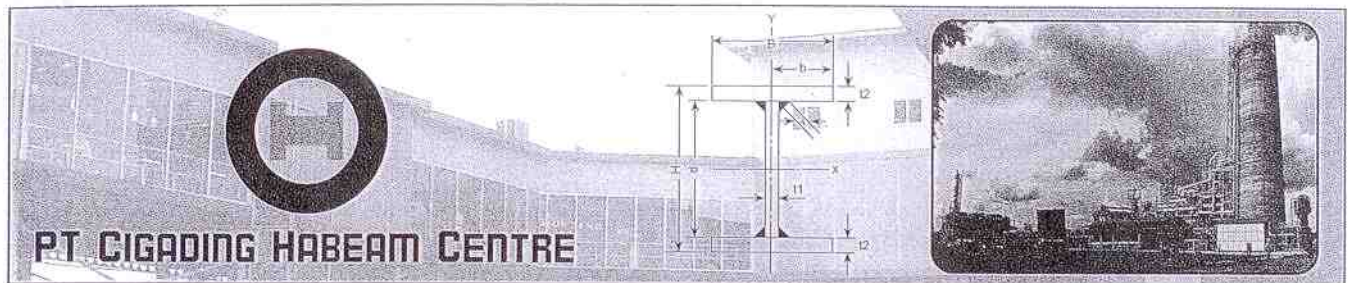
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
950	250	6.0.0	9.0.0	5.0	101.42	79.6	140097.528	2345.428	37.2	4.81	2949.422	187.6
950	250	6.0.0	12.0.0	5.0	116.06	91.1	171684.939	3126.667	38.5	5.19	3614.420	250.1
950	250	6.0.0	16.0.0	5.0	135.68	106.4	213169.298	4168.319	39.7	5.54	4487.775	333.5
950	250	6.0.0	19.0.0	5.0	150.44	117.9	243811.843	4949.558	40.3	5.74	5132.881	396.0
950	250	9.0.0	12.0.0	6.3	144.13	113.1	191535.508	3130.625	36.5	4.66	4032.326	250.5
950	250	9.0.0	16.0.0	6.3	163.41	128.3	232509.814	4172.244	37.7	5.05	4894.943	333.8
950	250	9.0.0	19.0.0	6.3	177.87	139.6	262775.606	4953.457	38.4	5.28	5532.118	396.3
950	250	9.0.0	22.0.0	6.3	192.52	151.0	292645.773	5734.671	39.0	5.46	6160.964	458.8
950	250	9.0.0	25.0.0	6.3	206.98	162.3	322122.917	6515.884	39.5	5.61	6781.535	521.3
950	250	12.0.0	16.0.0	8.4	191.57	150.4	251850.330	4179.886	36.3	4.67	5302.112	334.4
950	250	12.0.0	19.0.0	8.4	205.85	161.6	281739.369	4961.049	37.0	4.91	5931.355	396.9
950	250	12.0.0	22.0.0	8.4	220.13	172.8	311237.708	5742.213	37.6	5.11	6552.373	459.4
950	250	12.0.0	25.0.0	8.4	234.41	184.0	340347.917	6523.377	38.1	5.28	7165.219	521.9
950	250	12.0.0	28.0.0	8.4	248.69	195.2	369072.565	7304.540	38.5	5.42	7769.949	584.4
950	250	12.0.0	32.0.0	8.4	267.73	210.2	406776.779	8346.092	39.0	5.58	8563.722	667.7
950	250	16.0.0	25.0.0	11.2	271.50	213.1	364647.917	6541.137	36.6	4.91	7676.798	523.3
950	250	16.0.0	28.0.0	11.2	285.54	224.2	392889.798	7322.182	37.1	5.06	8271.364	585.8
950	250	16.0.0	32.0.0	11.2	304.26	238.9	429960.327	8363.575	37.6	5.24	9051.796	669.1
950	250	16.0.0	36.0.0	11.2	322.98	253.5	466367.420	9404.969	38.0	5.40	9818.261	752.4
950	250	16.0.0	38.0.0	11.2	332.34	260.9	484324.050	9925.666	38.2	5.46	10196.296	794.1
950	300	6.0.0	9.0.0	5.0	110.42	86.7	160021.458	4051.678	38.1	6.06	3368.873	270.1
950	300	6.0.0	12.0.0	5.0	128.06	100.5	198081.699	5401.667	39.3	6.49	4170.141	360.1
950	300	6.0.0	16.0.0	5.0	151.68	119.0	248066.952	7201.652	40.5	6.89	5222.462	480.1
950	300	6.0.0	19.0.0	5.0	169.44	132.8	284988.706	8551.642	41.0	7.11	5999.762	570.1
950	300	9.0.0	12.0.0	6.3	156.13	122.6	217932.268	5405.625	37.4	5.88	4588.048	360.4
950	300	9.0.0	16.0.0	6.3	179.41	140.8	267407.467	7205.577	38.6	6.34	5629.631	480.4
950	300	9.0.0	19.0.0	6.3	196.87	154.5	303952.470	8555.540	39.3	6.59	6398.999	570.4
950	300	9.0.0	22.0.0	6.3	214.52	168.3	340019.766	9905.504	39.8	6.80	7158.311	660.4
950	300	9.0.0	25.0.0	6.3	231.98	182.0	375612.50	11255.468	40.3	6.97	7907.632	750.4
950	300	12.0.0	16.0.0	8.4	207.57	162.9	286747.983	7213.219	37.2	5.89	6036.80	480.9
950	300	12.0.0	19.0.0	8.4	224.85	176.5	322916.233	8563.133	37.9	6.17	6798.236	570.9
950	300	12.0.0	22.0.0	8.4	242.13	190.1	358611.702	9913.046	38.5	6.40	7549.720	660.9
950	300	12.0.0	25.0.0	8.4	259.41	203.6	393837.50	11262.960	39.0	6.59	8291.316	750.9
950	300	12.0.0	28.0.0	8.4	276.69	217.2	428596.738	12612.874	39.4	6.75	9023.089	840.9
950	300	12.0.0	32.0.0	8.4	299.73	235.3	474222.006	14412.758	39.8	6.93	9983.621	960.9
950	300	16.0.0	25.0.0	11.2	296.50	232.8	418137.50	11280.720	37.6	6.17	8802.895	752.0
950	300	16.0.0	28.0.0	11.2	313.54	246.1	452413.971	12630.515	38.0	6.35	9524.505	842.0



PT CIGADING HABEAM CENTRE

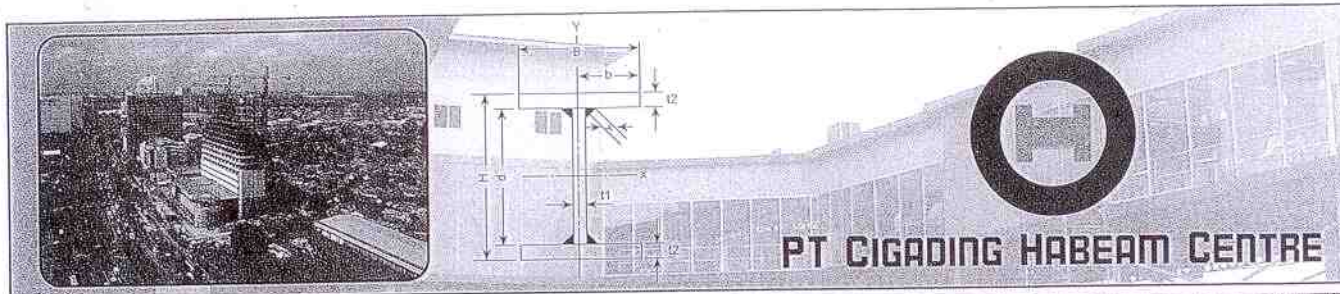
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
950	300	16.0.0	32.0.0	11.2	336.26	264.0	497405.554	14430.242	38.5	6.55	10471.696	962.0
950	300	16.0.0	36.0.0	11.2	358.98	281.8	541591.940	16229.969	38.8	6.72	11401.936	1082.0
950	300	16.0.0	38.0.0	11.2	370.34	290.7	563385.457	17129.833	39.0	6.80	11860.746	1142.0
950	350	6.0.0	9.0.0	5.0	119.42	93.7	179945.388	6432.928	38.8	7.34	3788.324	367.6
950	350	6.0.0	12.0.0	5.0	140.06	109.9	224478.459	8576.667	40.0	7.83	4725.862	490.1
950	350	6.0.0	16.0.0	5.0	167.68	131.6	282964.605	11434.986	41.1	8.26	5957.150	653.4
950	350	6.0.0	19.0.0	5.0	188.44	147.8	326165.570	13578.725	41.6	8.49	6866.644	775.9
950	350	9.0.0	12.0.0	6.3	168.13	132.0	244329.028	8580.625	38.1	7.14	5143.769	490.3
950	350	9.0.0	16.0.0	6.3	195.41	153.4	302305.121	11438.910	39.3	7.65	6364.318	653.7
950	350	9.0.0	19.0.0	6.3	215.87	169.5	345129.333	13582.624	40.0	7.93	7265.881	776.1
950	350	9.0.0	22.0.0	6.3	236.52	185.5	387393.760	15726.337	40.5	8.16	8155.658	898.6
950	350	9.0.0	25.0.0	6.3	256.98	201.6	429102.083	17870.051	40.9	8.34	9033.728	1021.1
950	350	12.0.0	16.0.0	8.4	223.57	175.5	321645.637	11446.553	37.9	7.16	6771.487	654.1
950	350	12.0.0	19.0.0	8.4	243.85	191.4	364093.096	13590.216	38.6	7.47	7665.118	776.6
950	350	12.0.0	22.0.0	8.4	264.13	207.3	405985.695	15733.880	39.2	7.72	8547.067	899.1
950	350	12.0.0	25.0.0	8.4	284.41	223.3	447327.083	17877.543	39.7	7.93	9417.412	1021.6
950	350	12.0.0	28.0.0	8.4	304.69	239.2	488120.912	20021.207	40.0	8.11	10276.230	1144.1
950	350	12.0.0	32.0.0	8.4	331.73	260.4	541667.232	22879.425	40.4	8.30	11403.521	1307.4
950	350	16.0.0	25.0.0	11.2	321.50	252.4	471627.083	17895.303	38.3	7.46	9928.991	1022.6
950	350	16.0.0	28.0.0	11.2	341.54	268.1	511938.145	20038.849	38.7	7.66	10777.645	1145.1
950	350	16.0.0	32.0.0	11.2	368.26	289.1	564850.781	22896.909	39.2	7.89	11891.595	1308.4
950	350	16.0.0	36.0.0	11.2	394.98	310.1	616816.460	25754.969	39.5	8.07	12985.610	1471.7
950	350	16.0.0	38.0.0	11.2	408.34	320.6	642446.863	27183.999	39.7	8.16	13525.197	1553.4
950	400	6.0.0	9.0.0	5.0	128.42	100.8	199869.318	9601.678	39.5	8.65	4207.775	480.1
950	400	6.0.0	12.0.0	5.0	152.06	119.4	250875.219	12801.667	40.6	9.18	5281.584	640.1
950	400	6.0.0	16.0.0	5.0	183.68	144.1	317862.258	17068.319	41.6	9.64	6691.837	853.4
950	400	6.0.0	19.0.0	5.0	207.44	162.7	367342.433	20268.308	42.1	9.89	7733.525	1013.4
950	400	9.0.0	12.0.0	6.3	180.13	141.4	270725.788	12805.625	38.8	8.43	5699.490	640.3
950	400	9.0.0	16.0.0	6.3	211.41	166.0	337202.774	17072.244	39.9	8.99	7099.006	853.6
950	400	9.0.0	19.0.0	6.3	234.87	184.4	386306.196	20272.207	40.6	9.29	8132.762	1013.6
950	400	9.0.0	22.0.0	6.3	258.52	202.8	434767.753	23472.171	41.0	9.53	9153.005	1173.6
950	400	9.0.0	25.0.0	6.3	281.98	221.2	482591.667	26672.134	41.4	9.73	10159.825	1333.6
950	400	12.0.0	16.0.0	8.4	239.57	188.1	356543.290	17079.886	38.6	8.44	7506.175	854.0
950	400	12.0.0	19.0.0	8.4	262.85	206.3	405269.959	20279.799	39.3	8.78	8531.999	1014.0
950	400	12.0.0	22.0.0	8.4	286.13	224.6	453359.688	23479.713	39.8	9.06	9544.414	1174.0
950	400	12.0.0	25.0.0	8.4	309.41	242.9	500816.667	26679.627	40.2	9.29	10543.509	1334.0
950	400	12.0.0	28.0.0	8.4	332.69	261.2	547645.085	29879.540	40.6	9.48	11529.370	1494.0
950	400	12.0.0	32.0.0	8.4	363.73	285.5	609112.459	34146.092	40.9	9.69	12823.420	1707.3



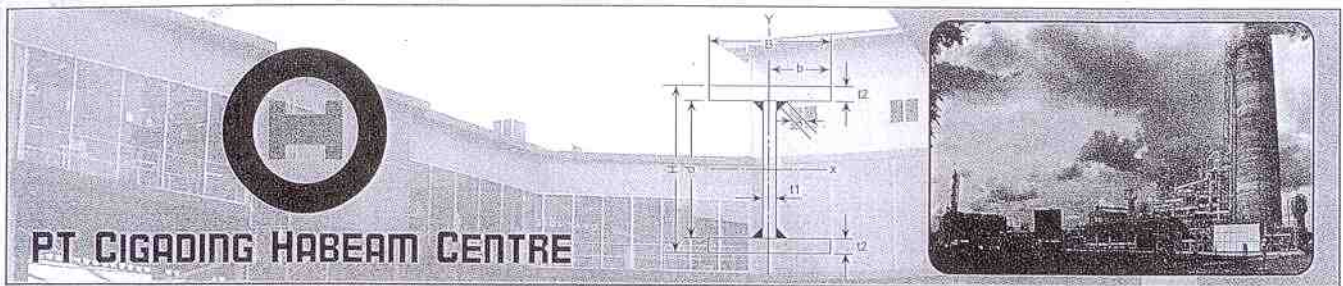
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
950	400	16.0.0	25.0.0	11.2	346.50	272.0	525116.667	26697.387	38.9	8.78	11055.088	1334.9
950	400	16.0.0	28.0.0	11.2	369.54	290.1	571462.318	29897.182	39.3	8.99	12030.786	1494.9
950	400	16.0.0	32.0.0	11.2	400.26	314.2	632296.007	34163.575	39.7	9.24	13311.495	1708.2
950	400	16.0.0	36.0.0	11.2	430.98	338.3	692040.980	38429.969	40.1	9.44	14569.284	1921.5
950	400	16.0.0	38.0.0	11.2	446.34	350.4	721508.270	40563.166	40.2	9.53	15189.648	2028.2
950	450	6.0.0	9.0.0	5.0	137.42	107.9	219793.248	13670.428	40.0	9.97	4627.226	607.6
950	450	6.0.0	12.0.0	5.0	164.06	128.8	277271.979	18226.667	41.1	10.54	5837.305	810.1
950	450	6.0.0	16.0.0	5.0	199.68	156.7	352759.912	24301.652	42.0	11.03	7426.524	1080.1
950	450	6.0.0	19.0.0	5.0	226.44	177.6	408519.296	28857.892	42.5	11.29	8600.406	1282.6
950	450	9.0.0	12.0.0	6.3	192.13	150.8	297122.548	18230.625	39.3	9.74	6255.212	810.3
950	450	9.0.0	16.0.0	6.3	227.41	178.5	372100.427	24305.577	40.5	10.34	7833.693	1080.2
950	450	9.0.0	19.0.0	6.3	253.87	199.3	427483.060	28861.790	41.0	10.66	8999.643	1282.7
950	450	9.0.0	22.0.0	6.3	281.85	220.1	482141.746	33418.004	41.5	10.92	10150.353	1485.2
950	450	9.0.0	25.0.0	6.3	306.98	240.8	536081.250	37974.218	41.8	11.13	11285.921	1687.7
950	450	12.0.0	16.0.0	8.4	255.57	200.6	391440.943	24313.219	39.1	9.75	8240.862	1080.6
950	450	12.0.0	19.0.0	8.4	280.82	221.3	446446.823	28869.383	39.8	10.12	9398.880	1283.1
950	450	12.0.0	22.0.0	8.4	308.13	241.9	500733.682	33425.546	40.3	10.42	10541.762	1485.6
950	450	12.0.0	25.0.0	8.4	334.41	262.5	554306.250	37981.710	40.7	10.66	11669.605	1688.1
950	450	12.0.0	28.0.0	8.4	360.69	283.1	607169.258	42537.874	41.0	10.86	12782.511	1890.6
950	450	12.0.0	32.0.0	8.4	395.73	310.6	676557.686	48612.758	41.3	11.08	14243.320	2160.6
950	450	16.0.0	25.0.0	11.2	371.50	291.6	578606.250	37999.470	39.5	10.11	12181.184	1688.9
950	450	16.0.0	28.0.0	11.2	397.54	312.1	630986.491	42555.515	39.8	10.35	13283.926	1891.4
950	450	16.0.0	32.0.0	11.2	432.26	339.3	699741.234	48630.242	40.2	10.61	14731.394	2161.3
950	450	16.0.0	36.0.0	11.2	466.98	366.6	767265.50	54704.969	40.5	10.82	16152.958	2431.3
950	450	16.0.0	38.0.0	11.2	484.34	380.2	800569.677	57742.333	40.7	10.92	16854.098	2566.3
1000	200	9.0.0	12.0.0	6.3	136.63	107.3	186871.603	1605.929	37.0	3.43	3737.432	160.6
1000	200	9.0.0	16.0.0	6.3	151.91	119.3	222962.556	2139.214	38.3	3.75	4459.251	213.9
1000	200	9.0.0	19.0.0	6.3	163.37	128.2	249642.238	2539.177	39.1	3.94	4992.845	253.9
1000	200	9.0.0	22.0.0	6.3	175.02	137.2	275991.185	2939.141	39.7	4.10	5519.824	293.9
1000	200	9.0.0	25.0.0	6.3	186.48	146.2	302011.458	3339.105	40.3	4.23	6040.229	333.9
1000	200	12.0.0	16.0.0	8.4	181.57	142.5	245638.537	2147.273	36.8	3.44	4912.771	214.7
1000	200	12.0.0	19.0.0	8.4	192.85	151.4	271899.166	2547.186	37.5	3.63	5437.983	254.7
1000	200	12.0.0	22.0.0	8.4	204.13	160.2	297834.255	2947.10	38.2	3.80	5956.685	294.7
1000	200	12.0.0	25.0.0	8.4	215.41	169.1	323445.833	3347.013	38.7	3.94	6468.917	334.7
1000	200	12.0.0	28.0.0	8.4	226.69	178.0	348735.932	3746.927	39.2	4.07	6974.719	374.7
1000	200	12.0.0	32.0.0	8.4	241.73	189.8	381959.492	4280.145	39.8	4.21	7639.190	428.0
1000	200	16.0.0	25.0.0	11.2	254.50	199.8	352025.0	3365.760	37.2	3.64	7040.50	336.6
1000	200	16.0.0	28.0.0	11.2	265.54	208.5	376777.011	3765.555	37.7	3.77	7535.540	376.6



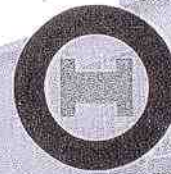
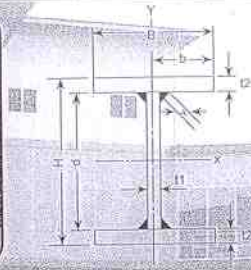
UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L.			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1000	200	16.0.0	32.0.0	11.2	280.26	220.0	409293.687	4298.615	38.2	3.92	8185.874	429.9
1000	200	16.0.0	36.0.0	11.2	294.98	231.6	441259.247	4831.676	38.7	4.05	8825.185	483.2
1000	200	16.0.0	38.0.0	11.2	302.34	237.3	457036.830	5098.206	38.9	4.11	9140.737	509.8
1000	250	9.0.0	12.0.0	6.3	148.63	116.7	216157.363	3130.929	38.1	4.59	4323.147	250.5
1000	250	9.0.0	16.0.0	6.3	167.91	131.8	261696.209	4172.547	39.5	4.98	5233.924	333.8
1000	250	9.0.0	19.0.0	6.3	182.37	143.2	295360.101	4953.761	40.2	5.21	5907.202	396.3
1000	250	9.0.0	22.0.0	6.3	197.02	154.5	328606.678	5734.974	40.9	5.40	6572.134	458.8
1000	250	9.0.0	25.0.0	6.3	211.48	165.9	361438.542	6516.188	41.4	5.55	7228.771	521.3
1000	250	12.0.0	16.0.0	8.4	197.57	155.1	284372.190	4180.606	37.9	4.60	5687.444	334.4
1000	250	12.0.0	19.0.0	8.4	211.85	166.3	317617.029	4961.769	38.7	4.84	6352.341	396.9
1000	250	12.0.0	22.0.0	8.4	226.13	177.5	350449.748	5742.933	39.4	5.04	7008.995	459.4
1000	250	12.0.0	25.0.0	8.4	240.41	188.7	382872.917	6524.097	39.9	5.21	7657.458	521.9
1000	250	12.0.0	28.0.0	8.4	254.69	199.9	414889.105	7305.260	40.4	5.36	8297.782	584.4
1000	250	12.0.0	32.0.0	8.4	273.73	214.9	456948.719	8346.812	40.9	5.52	9138.974	667.7
1000	250	16.0.0	25.0.0	11.2	279.50	219.4	411452.083	6542.843	38.4	4.84	8229.042	523.4
1000	250	16.0.0	28.0.0	11.2	293.54	230.4	442930.185	7323.889	38.8	4.99	8858.604	585.9
1000	250	16.0.0	32.0.0	11.2	312.26	245.1	484282.914	8365.282	39.4	5.18	9685.658	669.2
1000	250	16.0.0	36.0.0	11.2	330.98	259.8	524934.767	9406.676	39.8	5.33	10498.695	752.5
1000	250	16.0.0	38.0.0	11.2	340.34	267.2	544999.737	9927.373	40.0	5.40	10899.995	794.2
1000	300	9.0.0	12.0.0	6.3	160.63	126.1	245443.123	5405.929	39.1	5.80	4908.862	360.4
1000	300	9.0.0	16.0.0	6.3	183.91	144.4	300429.862	7205.881	40.4	6.26	6008.597	480.4
1000	300	9.0.0	19.0.0	6.3	201.37	158.1	341077.965	8555.844	41.2	6.52	6821.559	570.4
1000	300	9.0.0	22.0.0	6.3	219.02	171.8	381222.171	9905.808	41.7	6.73	7624.443	660.4
1000	300	9.0.0	25.0.0	6.3	236.48	185.5	420865.625	11255.771	42.2	6.90	8417.313	750.4
1000	300	12.0.0	16.0.0	8.4	213.57	167.7	323105.843	7213.939	38.9	5.81	6462.117	480.9
1000	300	12.0.0	19.0.0	8.4	230.85	181.2	363334.893	8563.853	39.7	6.09	7266.698	570.9
1000	300	12.0.0	22.0.0	8.4	248.13	194.8	403065.242	9913.766	40.3	6.32	8061.305	660.9
1000	300	12.0.0	25.0.0	8.4	265.41	208.3	442300.0	11263.680	40.8	6.51	8846.0	750.9
1000	300	12.0.0	28.0.0	8.4	282.69	221.9	481042.278	12613.594	41.3	6.68	9620.846	840.9
1000	300	12.0.0	32.0.0	8.4	305.73	240.0	531937.946	14413.478	41.7	6.87	10638.759	960.9
1000	300	16.0.0	25.0.0	11.2	304.50	239.0	470879.167	11282.427	39.3	6.09	9417.583	752.2
1000	300	16.0.0	28.0.0	11.2	321.54	252.4	509083.358	12632.222	39.8	6.27	10181.667	842.1
1000	300	16.0.0	32.0.0	11.2	344.26	270.3	559272.141	14431.949	40.3	6.47	11185.443	962.1
1000	300	16.0.0	36.0.0	11.2	366.98	288.1	608610.287	16231.676	40.7	6.65	12172.206	1082.1
1000	300	16.0.0	38.0.0	11.2	378.34	297.0	632962.643	17131.539	40.9	6.73	12659.253	1142.1
1000	350	9.0.0	12.0.0	6.3	172.63	135.5	274728.883	8580.929	39.9	7.05	5494.578	490.3
1000	350	9.0.0	16.0.0	6.3	199.91	156.9	339163.516	11439.214	41.2	7.56	6783.270	653.7
1000	350	9.0.0	19.0.0	6.3	220.37	173.0	386795.828	13582.927	41.9	7.85	7735.917	776.2



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1000	350	9.0.0	22.0.0	6.3	241.02	189.1	433837.665	15726.641	42.4	8.08	8676.753	898.7
1000	350	9.0.0	25.0.0	6.3	261.48	205.1	480292.708	17870.355	42.9	8.27	9605.854	1021.2
1000	350	12.0.0	16.0.0	8.4	229.57	180.2	361839.497	11447.273	39.7	7.06	7236.790	654.1
1000	350	12.0.0	19.0.0	8.4	249.85	196.1	409052.756	13590.936	40.5	7.38	8181.055	776.6
1000	350	12.0.0	22.0.0	8.4	270.13	212.1	455680.735	15734.60	41.1	7.63	9113.615	899.1
1000	350	12.0.0	25.0.0	8.4	290.41	228.0	501727.083	17878.263	41.6	7.85	10034.542	1021.6
1000	350	12.0.0	28.0.0	8.4	310.69	243.9	547195.452	20021.927	42.0	8.03	10943.909	1144.1
1000	350	12.0.0	32.0.0	8.4	337.73	265.1	606927.172	22880.145	42.4	8.23	12138.543	1307.4
1000	350	16.0.0	25.0.0	11.2	329.50	258.7	530306.250	17897.010	40.1	7.37	10606.125	1022.7
1000	350	16.0.0	28.0.0	11.2	349.54	274.4	575236.531	20040.555	40.6	7.57	11504.731	1145.2
1000	350	16.0.0	32.0.0	11.2	376.26	295.4	634261.367	22898.615	41.1	7.80	12685.227	1308.5
1000	350	16.0.0	36.0.0	11.2	402.98	316.3	692285.807	25756.676	41.4	7.99	13845.716	1471.8
1000	350	16.0.0	38.0.0	11.2	416.34	326.8	720925.550	27185.706	41.6	8.08	14418.511	1553.5
1000	400	9.0.0	12.0.0	6.3	184.63	144.9	304014.643	12805.929	40.6	8.33	6080.293	640.3
1000	400	9.0.0	16.0.0	6.3	215.91	169.5	377897.169	17072.547	41.8	8.89	7557.943	853.6
1000	400	9.0.0	19.0.0	6.3	239.37	187.9	432513.691	20272.511	42.5	9.20	8650.274	1013.6
1000	400	9.0.0	22.0.0	6.3	263.02	206.3	486453.158	23472.474	43.0	9.45	9729.063	1173.6
1000	400	9.0.0	25.0.0	6.3	286.48	224.7	539719.792	26672.438	43.4	9.65	10794.396	1333.6
1000	400	12.0.0	16.0.0	8.4	245.57	192.8	400573.150	17080.606	40.4	8.34	8011.463	854.0
1000	400	12.0.0	19.0.0	8.4	268.85	211.0	454770.619	20280.519	41.1	8.69	9095.412	1014.0
1000	400	12.0.0	22.0.0	8.4	292.13	229.3	508296.228	23480.433	41.7	8.97	10165.925	1174.0
1000	400	12.0.0	25.0.0	8.4	315.41	247.6	561154.167	26680.347	42.2	9.20	11223.083	1334.0
1000	400	12.0.0	28.0.0	8.4	338.69	265.9	613348.625	29880.260	42.6	9.39	12266.973	1494.0
1000	400	12.0.0	32.0.0	8.4	369.73	290.2	681916.399	34146.812	42.9	9.61	13638.328	1707.3
1000	400	16.0.0	25.0.0	11.2	354.50	278.3	589733.333	26699.093	40.8	8.68	11794.667	1335.0
1000	400	16.0.0	28.0.0	11.2	377.54	296.4	641389.705	29898.889	41.2	8.90	12827.794	1494.9
1000	400	16.0.0	32.0.0	11.2	408.26	320.5	709250.594	34165.282	41.7	9.15	14185.012	1708.3
1000	400	16.0.0	36.0.0	11.2	438.98	344.6	775961.327	38431.676	42.0	9.36	15519.227	1921.6
1000	400	16.0.0	38.0.0	11.2	454.34	356.7	808888.457	40564.873	42.2	9.45	16177.769	2028.2
1000	450	9.0.0	12.0.0	6.3	196.63	154.4	333300.403	18230.929	41.2	9.63	6666.008	810.3
1000	450	9.0.0	16.0.0	6.3	231.91	182.1	416630.822	24305.881	42.4	10.24	8332.616	1080.3
1000	450	9.0.0	19.0.0	6.3	258.37	202.8	478231.555	28862.094	43.0	10.57	9564.631	1282.8
1000	450	9.0.0	22.0.0	6.3	285.02	223.6	539068.651	33418.308	43.5	10.83	10781.373	1485.3
1000	450	9.0.0	25.0.0	6.3	311.48	244.4	599146.875	37974.521	43.9	11.04	11982.938	1687.8
1000	450	12.0.0	16.0.0	8.4	261.57	205.3	439306.803	24313.939	41.0	9.64	8786.136	1080.6
1000	450	12.0.0	19.0.0	8.4	287.85	226.0	500488.483	28870.103	41.7	10.01	10009.770	1283.1
1000	450	12.0.0	22.0.0	8.4	314.13	246.6	560911.722	33426.266	42.3	10.32	11218.234	1485.6
1000	450	12.0.0	25.0.0	8.4	340.41	267.2	620581.250	37982.430	42.7	10.56	12411.625	1688.1
1000	450	12.0.0	28.0.0	8.4	366.69	287.9	679501.798	42538.594	43.0	10.77	13590.036	1890.6



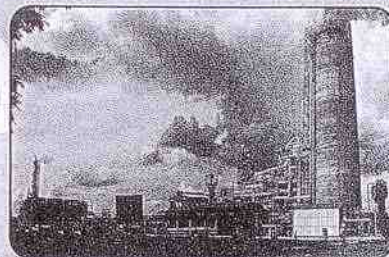
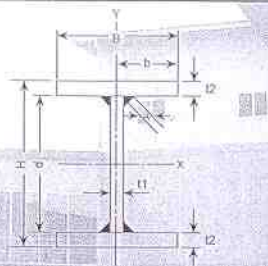
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	Ix	Iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1000	450	12.0.0	32.0.0	8.4	401.73	315.4	756905.626	48613.478	43.4	11.00	15138.113	2160.6
1000	450	16.0.0	25.0.0	11.2	379.50	297.9	649160.417	38001.177	41.4	10.01	12983.208	1688.9
1000	450	16.0.0	28.0.0	11.2	405.54	318.4	707542.878	42557.222	41.8	10.24	14150.858	1891.4
1000	450	16.0.0	32.0.0	11.2	440.26	345.6	784239.821	48631.949	42.2	10.51	15684.796	2161.4
1000	450	16.0.0	36.0.0	11.2	474.98	372.9	859636.847	54706.676	42.5	10.73	17192.737	2431.4
1000	450	16.0.0	38.0.0	11.2	492.34	386.5	896851.363	57744.039	42.7	10.83	17937.027	2566.4
1050	200	9.0.0	12.0.0	6.3	141.13	110.8	210302.458	1606.233	38.6	3.37	4005.761	160.6
1050	200	9.0.0	16.0.0	6.3	156.41	122.8	250201.951	2139.518	40.0	3.70	4765.751	214.0
1050	200	9.0.0	19.0.0	6.3	167.87	131.8	279717.983	2539.481	40.8	3.89	5327.962	253.9
1050	200	9.0.0	22.0.0	6.3	179.52	140.8	308886.090	2939.445	41.5	4.05	5883.545	293.9
1050	200	9.0.0	25.0.0	6.3	190.98	149.8	337708.333	3339.408	42.1	4.18	6432.540	333.9
1050	200	12.0.0	16.0.0	8.4	187.57	147.2	276576.397	2147.993	38.4	3.38	5268.122	214.8
1050	200	12.0.0	19.0.0	8.4	198.85	156.1	305628.826	2547.906	39.2	3.58	5821.501	254.8
1050	200	12.0.0	22.0.0	8.4	210.13	165.0	334338.795	2947.820	39.9	3.75	6368.358	294.8
1050	200	12.0.0	25.0.0	8.4	221.41	173.8	362708.333	3347.733	40.5	3.89	6908.730	334.8
1050	200	12.0.0	28.0.0	8.4	232.69	182.7	390739.472	3747.647	41.0	4.01	7442.657	374.8
1050	200	12.0.0	32.0.0	8.4	247.73	194.5	427591.432	4280.865	41.5	4.16	8144.599	428.1
1050	200	16.0.0	25.0.0	11.2	262.50	206.1	396041.667	3367.467	38.8	3.58	7543.651	336.7
1050	200	16.0.0	28.0.0	11.2	273.54	214.7	423476.398	3767.262	39.3	3.71	8066.217	376.7
1050	200	16.0.0	32.0.0	11.2	288.26	226.3	459544.274	4300.322	39.9	3.86	8753.224	430.0
1050	200	16.0.0	36.0.0	11.2	302.98	237.8	495031.594	4833.382	40.4	3.99	9429.173	483.3
1050	200	16.0.0	38.0.0	11.2	310.34	243.6	512559.017	5099.913	40.6	4.05	9763.029	510.0
1050	250	9.0.0	12.0.0	6.3	153.13	120.2	242627.218	3131.233	39.8	4.52	4621.471	250.5
1050	250	9.0.0	16.0.0	6.3	172.41	135.3	292971.604	4172.851	41.2	4.92	5580.412	333.8
1050	250	9.0.0	19.0.0	6.3	186.87	146.7	330214.346	4954.065	42.0	5.15	6289.797	396.3
1050	250	9.0.0	22.0.0	6.3	201.52	158.0	367018.083	5735.278	42.7	5.34	6990.821	458.8
1050	250	9.0.0	25.0.0	6.3	215.98	169.4	403385.417	6516.492	43.2	5.50	7683.532	521.3
1050	250	12.0.0	16.0.0	8.4	203.57	159.8	319346.050	4181.326	39.6	4.53	6082.782	334.5
1050	250	12.0.0	19.0.0	8.4	217.85	171.0	356125.189	4962.489	40.4	4.77	6783.337	397.0
1050	250	12.0.0	22.0.0	8.4	232.13	182.2	392470.788	5743.653	41.1	4.97	7475.634	459.5
1050	250	12.0.0	25.0.0	8.4	246.41	193.4	428385.417	6524.817	41.7	5.15	8159.722	522.0
1050	250	12.0.0	28.0.0	8.4	260.69	204.6	463871.645	7305.980	42.2	5.29	8835.650	584.5
1050	250	12.0.0	32.0.0	8.4	279.73	219.6	510524.659	8347.532	42.7	5.46	9724.279	667.8
1050	250	16.0.0	25.0.0	11.2	287.50	225.7	461718.750	6544.550	40.1	4.77	8794.643	523.6
1050	250	16.0.0	28.0.0	11.2	301.54	236.7	496608.571	7325.595	40.6	4.93	9459.211	586.0
1050	250	16.0.0	32.0.0	11.2	320.26	251.4	542477.501	8366.989	41.2	5.11	10332.905	669.4
1050	250	16.0.0	36.0.0	11.2	338.98	266.1	587608.114	9408.382	41.6	5.27	11192.535	752.7
1050	250	16.0.0	38.0.0	11.2	342.34	273.5	609898.423	9929.079	41.8	5.34	11617.113	794.3

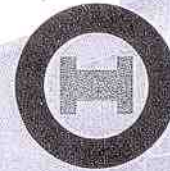
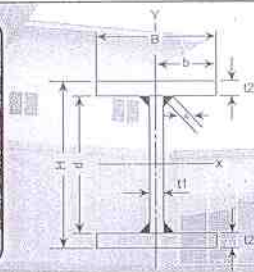


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION	WEIGHT PER METER	Inertia Moment		Gyraton Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S	(cm ²)	(kg/m)	(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1050	300	9.0.0	12.0.0	6.3	165.13	129.6	274951.978	5406.233	40.8	5.72	5237.181	360.4
1050	300	9.0.0	16.0.0	6.3	188.41	147.9	335741.257	7206.184	42.2	6.18	6395.072	480.4
1050	300	9.0.0	19.0.0	6.3	205.87	161.6	380710.710	8556.148	43.0	6.45	7251.633	570.4
1050	300	9.0.0	22.0.0	6.3	223.52	175.3	425150.076	9906.111	43.6	6.66	8098.097	660.4
1050	300	9.0.0	25.0.0	6.3	240.98	189.0	469062.50	11256.075	44.1	6.84	8934.524	750.4
1050	300	12.0.0	16.0.0	8.4	219.57	172.4	362115.703	7214.659	40.6	5.73	6897.442	481.0
1050	300	12.0.0	19.0.0	8.4	236.85	185.9	406621.553	8564.573	41.4	6.01	7745.172	571.0
1050	300	12.0.0	22.0.0	8.4	254.13	199.5	450602.782	9914.486	42.1	6.25	8582.910	661.0
1050	300	12.0.0	25.0.0	8.4	271.41	213.1	494062.50	11264.40	42.7	6.44	9410.714	751.0
1050	300	12.0.0	28.0.0	8.4	288.69	226.6	537003.818	12614.314	43.1	6.61	10228.644	841.0
1050	300	12.0.0	32.0.0	8.4	311.73	244.7	593457.886	14414.198	43.6	6.80	11303.960	960.9
1050	300	16.0.0	25.0.0	11.2	312.50	245.3	527395.833	11284.133	41.1	6.01	10045.635	752.3
1050	300	16.0.0	28.0.0	11.2	329.54	258.7	569740.745	12633.929	41.6	6.19	10852.205	842.3
1050	300	16.0.0	32.0.0	11.2	352.26	276.5	625410.727	14433.655	42.1	6.40	11912.585	962.2
1050	300	16.0.0	36.0.0	11.2	374.98	294.4	680184.634	16233.382	42.6	6.58	12955.898	1082.2
1050	300	16.0.0	38.0.0	11.2	386.34	303.3	707237.830	17133.246	42.8	6.66	13471.197	1142.2
1050	350	9.0.0	12.0.0	6.3	177.13	139.1	307276.738	8581.233	41.6	6.96	5852.890	490.4
1050	350	9.0.0	16.0.0	6.3	204.41	160.5	378510.911	11439.518	43.0	7.48	7209.732	653.7
1050	350	9.0.0	19.0.0	6.3	224.87	176.5	431207.073	13583.231	43.8	7.77	8213.468	776.2
1050	350	9.0.0	22.0.0	6.3	245.52	192.6	483282.070	15726.945	44.4	8.01	9205.373	898.7
1050	350	9.0.0	25.0.0	6.3	265.98	208.6	534739.583	17870.658	44.9	8.20	10185.516	1021.2
1050	350	12.0.0	16.0.0	8.4	235.57	184.9	404885.357	11447.993	41.5	6.97	7712.102	654.2
1050	350	12.0.0	19.0.0	8.4	255.85	200.8	457117.916	13591.656	42.3	7.29	8707.008	776.7
1050	350	12.0.0	22.0.0	8.4	276.13	216.8	508734.775	15735.320	42.9	7.55	9690.186	899.2
1050	350	12.0.0	25.0.0	8.4	296.41	232.7	559739.583	17878.983	43.5	7.77	10661.706	1021.7
1050	350	12.0.0	28.0.0	8.4	316.69	248.6	610135.992	20022.647	43.9	7.95	11621.638	1144.2
1050	350	12.0.0	32.0.0	8.4	343.73	269.8	676391.112	22880.865	44.4	8.16	12883.640	1307.5
1050	350	16.0.0	25.0.0	11.2	337.50	264.9	593072.917	17898.717	41.9	7.28	11296.627	1022.8
1050	350	16.0.0	28.0.0	11.2	357.54	280.7	642872.918	20042.262	42.4	7.49	12245.198	1145.3
1050	350	16.0.0	32.0.0	11.2	384.26	301.7	708343.954	22900.322	42.9	7.72	13492.266	1308.6
1050	350	16.0.0	36.0.0	11.2	410.98	322.6	772761.154	25758.382	43.4	7.92	14719.260	1471.9
1050	350	16.0.0	38.0.0	11.2	424.34	333.1	804577.237	27187.413	43.5	8.00	15325.281	1553.6
1050	400	9.0.0	12.0.0	6.3	189.13	148.5	339601.498	12806.233	42.4	8.23	6468.60	640.3
1050	400	9.0.0	16.0.0	6.3	220.41	173.0	421280.564	17072.851	43.7	8.80	8024.392	853.6
1050	400	9.0.0	19.0.0	6.3	243.87	191.4	481703.436	20272.815	44.4	9.12	9175.304	1013.6
1050	400	9.0.0	22.0.0	6.3	267.52	209.9	541414.063	23472.778	45.0	9.37	10312.649	1173.6
1050	400	9.0.0	25.0.0	6.3	290.98	228.3	600416.667	26672.742	45.4	9.58	11436.508	1333.6
1050	400	12.0.0	16.0.0	8.4	251.57	197.5	447655.010	17081.326	42.2	8.24	8526.762	854.1
1050	400	12.0.0	19.0.0	8.4	274.85	215.8	507614.279	20281.239	43.0	8.59	9668.843	1014.1



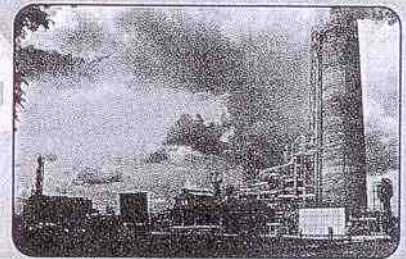
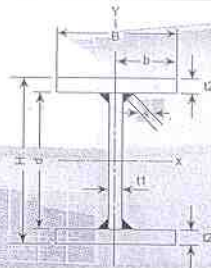
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1050	400	12.0.0	22.0.0	8.4	298.13	234.0	566866.768	23481.153	43.6	8.87	10797.462	1174.1
1050	400	12.0.0	25.0.0	8.4	321.41	252.3	625416.667	26681.067	44.1	9.11	11912.698	1334.1
1050	400	12.0.0	28.0.0	8.4	344.69	270.6	683268.165	29880.980	44.5	9.31	13014.632	1494.0
1050	400	12.0.0	32.0.0	8.4	375.73	294.9	759324.339	34147.532	45.0	9.53	14463.321	1707.4
1050	400	16.0.0	25.0.0	11.2	362.50	284.6	658750.0	26700.80	42.6	8.58	12547.619	1335.0
1050	400	16.0.0	28.0.0	11.2	385.54	302.7	716005.091	29900.595	43.1	8.81	13638.192	1495.0
1050	400	16.0.0	32.0.0	11.2	416.26	326.8	791277.181	34166.989	43.6	9.06	15071.946	1708.3
1050	400	16.0.0	36.0.0	11.2	446.98	350.9	865337.674	38433.382	44.0	9.27	16482.622	1921.7
1050	400	16.0.0	38.0.0	11.2	462.34	362.9	901916.643	40566.579	44.2	9.37	17179.365	2028.3
1050	450	9.0.0	12.0.0	6.3	201.13	157.9	371926.258	18231.233	43.0	9.52	7084.310	810.3
1050	450	9.0.0	16.0.0	6.3	236.41	185.6	464050.217	24306.184	44.3	10.14	8839.052	1080.3
1050	450	9.0.0	19.0.0	6.3	262.87	206.4	532199.80	28862.398	45.0	10.48	10137.139	1282.8
1050	450	9.0.0	22.0.0	6.3	289.52	227.1	599546.056	33418.611	45.5	10.75	11419.925	1485.3
1050	450	9.0.0	25.0.0	6.3	315.98	247.9	666093.750	37974.825	45.9	10.97	12687.50	1687.8
1050	450	12.0.0	16.0.0	8.4	267.57	210.0	490424.663	24314.659	42.8	9.53	9341.422	1080.7
1050	450	12.0.0	19.0.0	8.4	293.85	230.7	558110.643	28870.823	43.6	9.91	10630.679	1283.1
1050	450	12.0.0	22.0.0	8.4	320.13	251.3	624998.762	33426.986	44.2	10.22	11904.738	1485.6
1050	450	12.0.0	25.0.0	8.4	346.41	271.9	691093.750	37983.150	44.7	10.47	13163.690	1688.1
1050	450	12.0.0	28.0.0	8.4	372.69	292.6	756400.338	42539.314	45.1	10.68	14407.625	1890.6
1050	450	12.0.0	32.0.0	8.4	407.73	320.1	842257.566	48614.198	45.5	10.92	16043.001	2160.6
1050	450	16.0.0	25.0.0	11.2	387.50	304.2	724427.083	38002.883	43.2	9.90	13798.611	1689.0
1050	450	16.0.0	28.0.0	11.2	413.54	324.6	789137.265	42558.929	43.7	10.14	15031.186	1891.5
1050	450	16.0.0	32.0.0	11.2	448.26	351.9	874210.407	48633.655	44.2	10.42	16651.627	2161.5
1050	450	16.0.0	36.0.0	11.2	482.98	379.1	957914.194	54708.382	44.5	10.64	18245.985	2431.5
1050	450	16.0.0	38.0.0	11.2	500.34	392.8	999256.050	57745.746	44.7	10.74	19033.449	2566.5
1100	200	9.0.0	12.0.0	6.3	145.63	114.3	235487.563	1606.537	40.2	3.32	4281.592	160.7
1100	200	9.0.0	16.0.0	6.3	160.91	126.3	279386.596	2139.821	41.7	3.65	5079.756	214.0
1100	200	9.0.0	19.0.0	6.3	172.37	135.3	311882.228	2539.785	42.5	3.84	5670.586	254.0
1100	200	9.0.0	22.0.0	6.3	184.02	144.3	344012.745	2939.749	43.3	4.00	6254.777	294.0
1100	200	9.0.0	25.0.0	6.3	195.48	153.3	375780.208	3339.712	43.9	4.14	6832.367	334.0
1100	200	12.0.0	16.0.0	8.4	193.57	152.0	309841.257	2148.713	40.0	3.33	5633.477	214.9
1100	200	12.0.0	19.0.0	8.4	204.85	160.8	341826.486	2548.626	40.8	3.53	6215.027	254.9
1100	200	12.0.0	22.0.0	8.4	216.13	169.7	373452.335	2948.540	41.6	3.69	6790.042	294.9
1100	200	12.0.0	25.0.0	8.4	227.41	178.5	404720.833	3348.453	42.2	3.84	7358.561	334.8
1100	200	12.0.0	28.0.0	8.4	238.69	187.4	435634.012	3748.367	42.7	3.96	7920.618	374.8
1100	200	12.0.0	32.0.0	8.4	253.73	199.2	476302.372	4281.585	43.3	4.11	8660.043	428.2
1100	200	16.0.0	25.0.0	11.2	270.50	212.3	443308.333	3369.173	40.5	3.53	8060.152	336.9
1100	200	16.0.0	28.0.0	11.2	281.54	221.0	473563.785	3768.969	41.0	3.66	8610.251	376.9
1100	200	16.0.0	32.0.0	11.2	296.26	232.6	513366.861	4302.029	41.6	3.81	9333.943	430.2

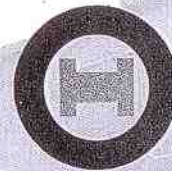
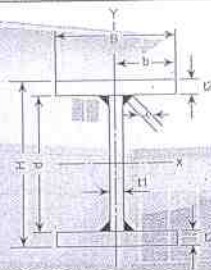


PT CIGADING HAKEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1100	200	16.0.0	36.0.0	11.2	310.98	244.1	552559.940	4835.089	42.2	3.94	10046.544	483.5
1100	200	16.0.0	38.0.0	11.2	318.34	249.9	571929.203	5101.619	42.4	4.00	10398.713	510.2
1100	250	9.0.0	12.0.0	6.3	157.63	123.7	271001.323	3131.537	41.5	4.46	4927.297	250.5
1100	250	9.0.0	16.0.0	6.3	176.91	138.9	326392.249	4173.155	43.0	4.86	5934.405	333.9
1100	250	9.0.0	19.0.0	6.3	191.37	150.2	367394.591	4954.368	43.8	5.09	6679.902	396.3
1100	250	9.0.0	22.0.0	6.3	206.02	161.6	407936.238	5735.582	44.5	5.28	7417.023	458.8
1100	250	9.0.0	25.0.0	6.3	220.48	172.9	448019.792	6516.795	45.1	5.44	8145.814	521.3
1100	250	12.0.0	16.0.0	8.4	209.57	164.5	356846.910	4182.046	41.3	4.47	6488.126	334.6
1100	250	12.0.0	19.0.0	8.4	223.85	175.72	397.338	4.963	42.2	4.72	7.224	397
1100	250	12.0.0	22.0.0	8.4	238.13	186.9	437375.828	5744.373	42.9	4.91	7952.288	459.5
1100	250	12.0.0	25.0.0	8.4	252.41	198.1	476960.417	6525.537	43.5	5.08	8672.008	522.0
1100	250	12.0.0	28.0.0	8.4	266.69	209.4	516095.185	7306.70	44.0	5.23	9383.549	584.5
1100	250	12.0.0	32.0.0	8.4	285.73	224.3	567579.599	8348.252	44.6	5.41	10319.629	667.9
1100	250	16.0.0	25.0.0	11.2	295.50	232.0	515547.917	6546.257	41.8	4.71	9373.598	523.7
1100	250	16.0.0	28.0.0	11.2	309.54	243.0	554024.958	7327.302	42.3	4.87	10073.181	586.2
1100	250	16.0.0	32.0.0	11.2	328.26	257.7	604644.087	8368.695	42.9	5.05	10993.529	669.5
1100	250	16.0.0	36.0.0	11.2	346.98	272.4	654487.460	9410.089	43.4	5.21	11899.772	752.8
1100	250	16.0.0	38.0.0	11.2	356.34	279.7	679120.110	9930.786	43.7	5.28	12347.638	794.5
1100	300	9.0.0	12.0.0	6.3	169.63	133.2	306515.083	5406.537	42.5	5.65	5573.002	360.4
1100	300	9.0.0	16.0.0	6.3	192.91	151.4	373397.902	7206.488	44.0	6.11	6789.053	480.4
1100	300	9.0.0	19.0.0	6.3	210.37	165.1	422906.955	8556.452	44.8	6.38	7689.217	570.4
1100	300	9.0.0	22.0.0	6.3	228.02	178.8	471859.731	9906.415	45.5	6.59	8579.268	660.4
1100	300	9.0.0	25.0.0	6.3	245.48	192.6	520259.375	11256.379	46.1	6.77	9459.261	750.4
1100	300	12.0.0	16.0.0	8.4	225.57	177.1	403852.563	7215.379	42.3	5.66	7342.774	481.0
1100	300	12.0.0	19.0.0	8.4	242.85	190.6	452851.213	8565.293	43.2	5.94	8233.658	571.0
1100	300	12.0.0	22.0.0	8.4	260.13	204.2	501299.322	9915.206	43.9	6.17	9114.533	661.0
1100	300	12.0.0	25.0.0	8.4	277.41	217.8	549200.0	11265.120	44.5	6.37	9985.455	751.0
1100	300	12.0.0	28.0.0	8.4	294.69	231.3	596556.358	12615.034	45.0	6.54	10846.479	841.0
1100	300	12.0.0	32.0.0	8.4	317.73	249.4	658856.826	14414.918	45.5	6.74	11979.215	961.0
1100	300	16.0.0	25.0.0	11.2	320.50	251.6	587787.50	11285.840	42.8	5.93	10687.045	752.4
1100	300	16.0.0	28.0.0	11.2	337.54	265.0	634486.131	12635.635	43.4	6.12	11536.111	842.4
1100	300	16.0.0	32.0.0	11.2	360.26	282.8	695921.314	14435.362	44.0	6.33	12653.115	962.4
1100	300	16.0.0	36.0.0	11.2	382.98	300.6	756414.980	16235.089	44.4	6.51	13753.0	1082.3
1100	300	16.0.0	38.0.0	11.2	394.34	309.6	786311.017	17134.953	44.7	6.59	14296.564	1142.3
1100	350	9.0.0	12.0.0	6.3	181.63	142.6	342028.843	8581.537	43.4	6.87	6218.706	490.4
1100	350	9.0.0	16.0.0	6.3	208.91	164.0	420403.556	11439.821	44.9	7.40	7643.701	653.7
1100	350	9.0.0	19.0.0	6.3	229.37	180.1	478419.318	13583.535	45.7	7.70	8698.533	776.2
1100	350	9.0.0	22.0.0	6.3	250.02	196.1	535783.225	15727.249	46.3	7.93	9741.513	898.7



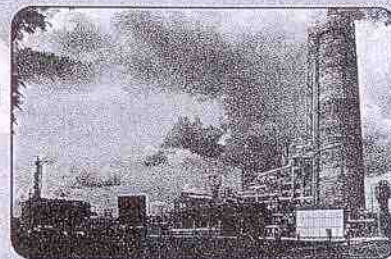
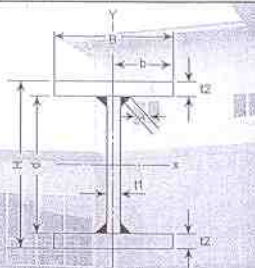
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1100	350	9.0.0	25.0.0	6.3	270.48	212.2	592498.958	17870.962	46.8	8.13	10772.708	1021.2
1100	350	12.0.0	16.0.0	8.4	241.57	189.6	450858.217	11448.713	43.2	6.88	8197.422	654.2
1100	350	12.0.0	19.0.0	8.4	261.85	205.6	508363.576	13592.376	44.1	7.20	9242.974	776.7
1100	350	12.0.0	22.0.0	8.4	282.13	221.5	565222.815	15736.040	44.8	7.47	10276.778	899.2
1100	350	12.0.0	25.0.0	8.4	302.41	237.4	621439.583	17879.703	45.3	7.69	11298.902	1021.7
1100	350	12.0.0	28.0.0	8.4	322.69	253.3	677017.532	20023.367	45.8	7.88	12309.410	1144.2
1100	350	12.0.0	32.0.0	8.4	349.73	274.5	750134.052	22881.585	46.3	8.09	13638.801	1307.5
1100	350	16.0.0	25.0.0	11.2	345.50	271.2	660027.083	17900.423	43.7	7.20	12000.492	1022.9
1100	350	16.0.0	28.0.0	11.2	365.54	287.0	714947.305	20043.969	44.2	7.40	12999.042	1145.4
1100	350	16.0.0	32.0.0	11.2	392.26	307.9	787198.541	22902.029	44.8	7.64	14312.701	1308.7
1100	350	16.0.0	36.0.0	11.2	418.98	328.9	858342.50	25760.089	45.3	7.84	15606.227	1472.0
1100	350	16.0.0	38.0.0	11.2	432.34	339.4	893501.923	27189.119	45.5	7.93	16245.490	1553.7
1100	400	9.0.0	12.0.0	6.3	193.63	152.0	377542.603	12806.537	44.2	8.13	6864.411	640.3
1100	400	9.0.0	16.0.0	6.3	224.91	176.6	467409.209	17073.155	45.6	8.71	8498.349	853.7
1100	400	9.0.0	19.0.0	6.3	248.37	195.0	533931.681	20273.118	46.4	9.03	9707.849	1013.7
1100	400	9.0.0	22.0.0	6.3	272.02	213.4	599706.718	23473.082	47.0	9.29	10903.759	1173.7
1100	400	9.0.0	25.0.0	6.3	295.48	231.8	664738.542	26673.045	47.4	9.50	12086.155	1333.7
1100	400	12.0.0	16.0.0	8.4	257.57	202.2	497863.870	17082.046	44.0	8.14	9052.070	854.1
1100	400	12.0.0	19.0.0	8.4	280.85	220.5	563875.939	20281.959	44.8	8.50	10252.290	1014.1
1100	400	12.0.0	22.0.0	8.4	304.13	238.7	629146.308	23481.873	45.5	8.79	11439.024	1174.1
1100	400	12.0.0	25.0.0	8.4	327.41	257.0	693679.167	26681.787	46.0	9.03	12612.348	1334.1
1100	400	12.0.0	28.0.0	8.4	350.69	275.3	757478.705	29881.70	46.5	9.23	13772.340	1494.1
1100	400	12.0.0	32.0.0	8.4	381.73	299.7	841411.279	34148.252	46.9	9.46	15298.387	1707.4
1100	400	16.0.0	25.0.0	11.2	370.50	290.8	732266.667	26702.507	44.5	8.49	13313.939	1335.1
1100	400	16.0.0	28.0.0	11.2	393.54	308.9	795408.478	29902.302	45.0	8.72	14461.972	1495.1
1100	400	16.0.0	32.0.0	11.2	424.26	333.1	878475.767	34168.695	45.5	8.97	15972.287	1708.4
1100	400	16.0.0	36.0.0	11.2	454.98	357.2	960270.020	38435.089	45.9	9.19	17459.455	1921.8
1100	400	16.0.0	38.0.0	11.2	470.34	369.2	1000692.830	40568.286	46.1	9.29	18194.415	2028.4
1100	450	9.0.0	12.0.0	6.3	205.63	161.4	413056.363	18231.537	44.8	9.42	7510.116	810.3
1100	450	9.0.0	16.0.0	6.3	240.91	189.1	514414.862	24306.488	46.2	10.04	9352.997	1080.3
1100	450	9.0.0	19.0.0	6.3	267.37	209.9	589444.045	28862.702	47.0	10.39	10717.164	1282.8
1100	450	9.0.0	22.0.0	6.3	294.02	230.7	663630.211	33418.915	47.5	10.66	12066.004	1485.3
1100	450	9.0.0	25.0.0	6.3	320.48	251.4	736978.125	37975.129	48.0	10.89	13399.602	1687.8
1100	450	12.0.0	16.0.0	8.4	273.57	214.8	544869.523	24315.379	44.6	9.43	9906.719	1080.7
1100	450	12.0.0	19.0.0	8.4	299.85	235.4	619388.303	28871.543	45.4	9.81	11261.606	1283.2
1100	450	12.0.0	22.0.0	8.4	326.13	256.0	693069.802	33427.706	46.1	10.12	12601.269	1485.7
1100	450	12.0.0	25.0.0	8.4	352.41	276.6	765918.750	37983.870	46.6	10.38	13925.795	1688.2
1100	450	12.0.0	28.0.0	8.4	378.69	297.3	837939.878	42540.034	47.0	10.60	15235.271	1890.7
1100	450	12.0.0	32.0.0	8.4	413.73	324.8	932688.506	48614.918	47.5	10.84	16957.973	2160.7

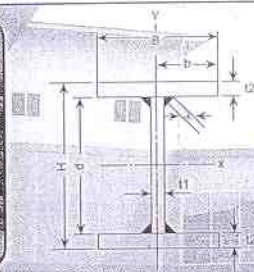


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

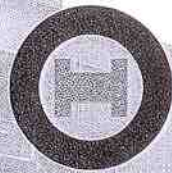
SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyratation Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1100	450	16.0.0	25.0.0	11.2	395.50	310.5	804506.250	38004.590	45.1	9.80	14627.386	1689.1
1100	450	16.0.0	28.0.0	11.2	421.54	330.9	875869.651	42560.635	45.6	10.05	15924.903	1891.6
1100	450	16.0.0	32.0.0	11.2	456.26	358.2	969752.994	48635.362	46.1	10.32	17631.873	2161.6
1100	450	16.0.0	36.0.0	11.2	490.98	385.4	1062197.540	54710.089	46.5	10.56	19312.683	2431.6
1100	450	16.0.0	38.0.0	11.2	508.34	399.1	1107883.737	57747.453	46.7	10.66	20143.341	2566.6
1150	200	9.0.0	12.0.0	6.3	150.13	117.9	262483.168	1606.840	41.8	3.27	4564.925	160.7
1150	200	9.0.0	16.0.0	6.3	165.41	129.8	310572.741	2140.125	43.3	3.60	5401.265	214.0
1150	200	9.0.0	19.0.0	6.3	176.87	138.8	346191.223	2540.089	44.2	3.79	6020.717	254.0
1150	200	9.0.0	22.0.0	6.3	188.52	147.8	381427.40	2940.052	45.0	3.95	6633.520	294.0
1150	200	9.0.0	25.0.0	6.3	199.98	156.8	416283.333	3340.016	45.6	4.09	7239.710	334.0
1150	200	12.0.0	16.0.0	8.4	199.57	156.7	345508.117	2149.433	41.6	3.28	6008.837	214.9
1150	200	12.0.0	19.0.0	8.4	210.85	165.5	380567.146	2549.346	42.5	3.48	6618.559	254.9
1150	200	12.0.0	22.0.0	8.4	222.13	174.4	415249.875	2949.260	43.2	3.64	7221.737	294.9
1150	200	12.0.0	28.0.0	8.4	244.69	192.1	483494.552	3749.087	44.5	3.91	8408.601	374.9
1150	200	12.0.0	32.0.0	8.4	259.73	203.9	528167.312	4282.305	45.1	4.06	9185.518	428.2
1150	200	16.0.0	25.0.0	11.2	278.50	218.6	493925.0	3370.880	42.1	3.48	8590.0	337.1
1150	200	16.0.0	28.0.0	11.2	289.54	227.3	527139.171	3770.675	42.7	3.61	9167.638	377.1
1150	200	16.0.0	32.0.0	11.2	304.26	238.9	570861.447	4303.735	43.3	3.76	9928.025	430.4
1150	200	16.0.0	36.0.0	11.2	318.98	250.4	613944.287	4836.796	43.9	3.89	10677.292	483.7
1150	200	16.0.0	38.0.0	11.2	326.34	256.2	635247.390	5103.326	44.1	3.95	11047.781	510.3
1150	250	9.0.0	12.0.0	6.3	162.13	127.3	301335.928	3131.840	43.1	4.40	5240.625	250.5
1150	250	9.0.0	16.0.0	6.3	181.41	142.4	362014.394	4173.459	44.7	4.80	6295.903	333.9
1150	250	9.0.0	19.0.0	6.3	195.87	153.8	406957.086	4954.672	45.6	5.03	7077.515	396.4
1150	250	9.0.0	22.0.0	6.3	210.52	165.1	451417.393	5735.886	46.3	5.22	7850.737	458.9
1150	250	9.0.0	25.0.0	6.3	224.98	176.5	495397.917	6517.099	46.9	5.38	8615.616	521.4
1150	250	12.0.0	16.0.0	8.4	215.57	169.2	396949.770	4182.766	42.9	4.40	6903.474	334.6
1150	250	12.0.0	19.0.0	8.4	229.85	180.4	441333.009	4963.929	43.8	4.65	7675.357	397.1
1150	250	12.0.0	22.0.0	8.4	244.13	191.6	485239.868	5745.093	44.6	4.85	8438.954	459.6
1150	250	12.0.0	25.0.0	8.4	258.41	202.9	528672.917	6526.257	45.2	5.03	9194.312	522.1
1150	250	12.0.0	28.0.0	8.4	272.69	214.1	571634.725	7307.420	45.8	5.18	9941.473	584.6
1150	250	12.0.0	32.0.0	8.4	291.73	229.0	628188.539	8348.972	46.4	5.35	10925.018	667.9
1150	250	16.0.0	25.0.0	11.2	303.50	238.3	573039.583	6547.963	43.5	4.64	9965.906	523.8
1150	250	16.0.0	28.0.0	11.2	317.54	249.3	615279.345	7329.009	44.0	4.80	10700.510	586.3
1150	250	16.0.0	32.0.0	11.2	336.26	264.0	670882.674	8370.402	44.7	4.99	11667.525	669.6
1150	250	16.0.0	36.0.0	11.2	354.98	278.7	725672.807	9411.796	45.2	5.15	12620.397	752.9
1150	250	16.0.0	38.0.0	11.2	364.34	286.0	752764.797	9932.493	45.5	5.22	13091.562	794.6



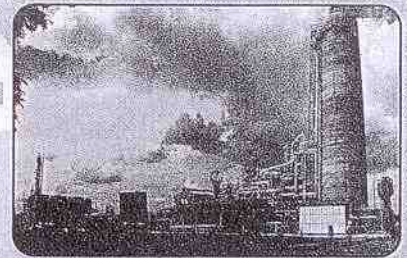
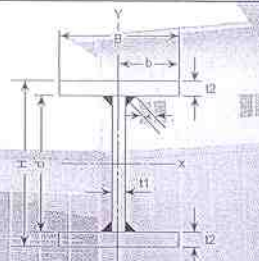
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1150	300	9.0.0	12.0.0	6.3	174.13	136.7	340188.688	5406.840	44.2	5.57	5916.325	360.5
1150	300	9.0.0	16.0.0	6.3	197.41	155.0	413456.047	7206.792	45.8	6.04	7190.540	480.5
1150	300	9.0.0	19.0.0	6.3	214.87	168.7	467722.950	8556.755	46.7	6.31	8134.312	570.5
1150	300	9.0.0	22.0.0	6.3	232.52	182.4	521407.386	9906.719	47.4	6.53	9067.955	660.4
1150	300	9.0.0	25.0.0	6.3	249.98	196.1	574512.50	11256.683	48.0	6.71	9991.522	750.4
1150	300	12.0.0	16.0.0	8.4	231.57	181.8	448391.423	7216.099	44.0	5.58	7798.112	481.1
1150	300	12.0.0	19.0.0	8.4	248.85	195.3	502098.873	8566.013	44.9	5.87	8732.154	571.1
1150	300	12.0.0	22.0.0	8.4	266.13	208.9	555229.862	9915.926	45.7	6.10	9656.172	661.1
1150	300	12.0.0	25.0.0	8.4	283.41	222.5	607787.50	11265.840	46.3	6.30	10570.217	751.1
1150	300	12.0.0	28.0.0	8.4	300.69	236.0	659774.898	12615.754	46.8	6.48	11474.346	841.1
1150	300	12.0.0	32.0.0	8.4	323.73	254.1	728209.766	14415.638	47.4	6.67	12664.518	961.0
1150	300	16.0.0	25.0.0	11.2	328.50	257.9	652154.167	11287.547	44.6	5.86	11341.812	752.5
1150	300	16.0.0	28.0.0	11.2	345.54	271.3	703419.518	12637.342	45.1	6.05	12233.383	842.5
1150	300	16.0.0	32.0.0	11.2	368.26	289.1	770903.901	14437.069	45.8	6.26	13407.024	962.5
1150	300	16.0.0	36.0.0	11.2	390.98	306.9	837401.327	16236.796	46.3	6.44	14563.501	1082.5
1150	300	16.0.0	38.0.0	11.2	402.34	315.8	870282.203	17136.659	46.5	6.53	15135.343	1142.4
1150	350	9.0.0	12.0.0	6.3	186.13	146.1	379041.448	8581.840	45.1	6.79	6592.025	490.4
1150	350	9.0.0	16.0.0	6.3	213.41	167.5	464897.701	11440.125	46.7	7.32	8085.177	653.7
1150	350	9.0.0	19.0.0	6.3	233.87	183.6	528488.813	13583.839	47.5	7.62	9191.110	776.2
1150	350	9.0.0	22.0.0	6.3	254.52	199.7	591397.380	15727.552	48.2	7.86	10285.172	898.7
1150	350	9.0.0	25.0.0	6.3	274.98	215.7	653627.083	17871.266	48.8	8.06	11367.428	1021.2
1150	350	12.0.0	16.0.0	8.4	247.57	194.3	499833.077	11449.433	44.9	6.80	8692.749	654.3
1150	350	12.0.0	19.0.0	8.4	267.85	210.3	562864.736	13593.096	45.8	7.12	9788.952	776.7
1150	350	12.0.0	22.0.0	8.4	288.13	226.2	625219.855	15736.760	46.6	7.39	10873.389	899.2
1150	350	12.0.0	25.0.0	8.4	308.41	242.1	686902.083	17880.423	47.2	7.61	11946.123	1021.7
1150	350	12.0.0	28.0.0	8.4	328.69	258.0	747915.072	20024.087	47.7	7.81	13007.219	1144.2
1150	350	12.0.0	32.0.0	8.4	355.73	279.2	828230.992	22882.305	48.3	8.02	14404.017	1307.6
1150	350	16.0.0	25.0.0	11.2	353.50	277.5	731268.750	17902.130	45.5	7.12	12717.717	1023.0
1150	350	16.0.0	28.0.0	11.2	373.54	293.2	791559.691	20045.675	46.0	7.33	13766.255	1145.5
1150	350	16.0.0	32.0.0	11.2	400.26	314.2	870925.127	22903.735	46.6	7.56	15146.524	1308.8
1150	350	16.0.0	36.0.0	11.2	426.98	335.2	949129.847	25761.796	47.1	7.77	16506.606	1472.1
1150	350	16.0.0	38.0.0	11.2	440.34	345.7	987799.610	27190.826	47.4	7.86	17179.124	1553.8
1150	400	9.0.0	12.0.0	6.3	198.13	155.5	417894.208	12806.840	45.9	8.04	7267.725	640.3
1150	400	9.0.0	16.0.0	6.3	229.41	180.1	516339.354	17073.459	47.4	8.63	8979.815	853.7
1150	400	9.0.0	19.0.0	6.3	252.87	198.5	589254.676	20273.422	48.3	8.95	10247.907	1013.7
1150	400	9.0.0	22.0.0	6.3	276.52	216.9	661387.373	23473.386	48.9	9.22	11502.389	1173.7
1150	400	9.0.0	25.0.0	6.3	299.98	235.3	732741.667	26673.349	49.4	9.43	12743.333	1333.7
1150	400	12.0.0	16.0.0	8.4	263.57	206.9	551274.730	17082.766	45.7	8.05	9587.387	854.1

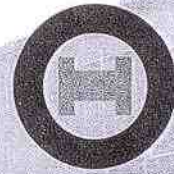
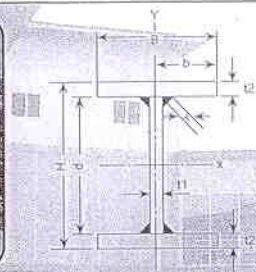
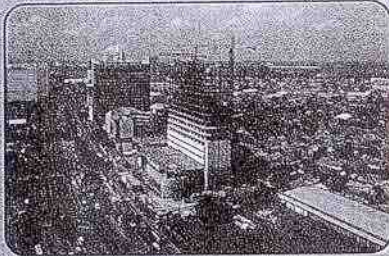


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1150	400	12.0.0	19.0.0	8.4	286.85	225.2	623630.599	20282.679	46.6	8.41	10845.750	1014.1
1150	400	12.0.0	22.0.0	8.4	310.13	243.5	695209.848	23482.593	47.3	8.70	12090.606	1174.1
1150	400	12.0.0	25.0.0	8.4	333.41	261.7	766016.667	26682.507	47.9	8.95	13322.029	1334.1
1150	400	12.0.0	28.0.0	8.4	356.69	280.0	836055.245	29882.420	48.4	9.15	14540.091	1494.1
1150	400	12.0.0	32.0.0	8.4	387.73	304.4	928252.219	34148.972	48.9	9.38	16143.517	1707.4
1150	400	16.0.0	25.0.0	11.2	378.50	297.1	810383.333	26704.213	46.3	8.40	14093.623	1335.2
1150	400	16.0.0	28.0.0	11.2	401.54	315.2	879699.865	29904.009	46.8	8.63	15299.128	1495.2
1150	400	16.0.0	32.0.0	11.2	432.26	339.3	970946.354	34170.402	47.4	8.89	16886.024	1708.5
1150	400	16.0.0	36.0.0	11.2	462.98	363.4	1060858.367	38436.796	47.9	9.11	18449.711	1921.8
1150	400	16.0.0	38.0.0	11.2	478.34	375.5	1105317.017	40569.993	48.1	9.21	19222.905	2028.5
1150	450	9.0.0	12.0.0	6.3	210.13	165.0	456746.968	18231.840	46.6	9.31	7943.426	810.3
1150	450	9.0.0	16.0.0	6.3	245.41	192.6	567781.007	24306.792	48.1	9.95	9874.452	1080.3
1150	450	9.0.0	19.0.0	6.3	271.87	213.4	650020.540	28863.005	48.9	10.30	11304.705	1282.8
1150	450	9.0.0	22.0.0	6.3	298.52	234.2	731377.366	33419.219	49.5	10.58	12719.606	1485.3
1150	450	9.0.0	25.0.0	6.3	324.98	255.0	811856.250	37975.433	50.0	10.81	14119.239	1687.8
1150	450	12.0.0	16.0.0	8.4	279.57	219.5	602716.383	24316.099	46.4	9.33	10482.024	1080.7
1150	450	12.0.0	19.0.0	8.4	305.85	240.1	684396.463	28872.263	47.3	9.72	11902.547	1283.2
1150	450	12.0.0	22.0.0	8.4	332.13	260.7	765199.842	33428.426	48.0	10.03	13307.823	1485.7
1150	450	12.0.0	25.0.0	8.4	358.41	281.4	845131.250	37984.590	48.6	10.29	14697.935	1688.2
1150	450	12.0.0	28.0.0	8.4	384.69	302.0	924195.418	42540.754	49.0	10.52	16072.964	1890.7
1150	450	12.0.0	32.0.0	8.4	419.73	329.5	1028273.446	48615.638	49.5	10.76	17883.016	2160.7
1150	450	16.0.0	25.0.0	11.2	403.50	316.8	889497.917	38006.297	47.0	9.71	15469.529	1689.2
1150	450	16.0.0	28.0.0	11.2	429.54	337.2	967840.038	42562.342	47.5	9.95	16832.001	1891.7
1150	450	16.0.0	32.0.0	11.2	464.26	364.5	1070967.581	48637.069	48.0	10.24	18625.523	2161.6
1150	450	16.0.0	36.0.0	11.2	498.98	391.7	1172586.887	54711.796	48.5	10.47	20392.815	2431.6
1150	450	16.0.0	38.0.0	11.2	516.34	405.3	1222834.423	57749.159	48.7	10.58	21266.686	2566.6
1200	200	9.0.0	12.0.0	6.3	154.63	121.4	291345.523	1607.144	43.4	3.22	4855.759	160.7
1200	200	9.0.0	16.0.0	6.3	169.91	133.4	343816.636	2140.429	45.0	3.55	5730.277	214.0
1200	200	9.0.0	19.0.0	6.3	181.37	142.4	382701.218	2540.392	45.9	3.74	6378.354	254.0
1200	200	9.0.0	22.0.0	6.3	193.02	151.4	421186.305	2940.356	46.7	3.90	7019.772	294.0
1200	200	9.0.0	25.0.0	6.3	204.48	160.4	459273.958	3340.320	47.4	4.04	7654.566	334.0
1200	200	12.0.0	16.0.0	8.4	205.57	161.4	383651.977	2150.153	43.2	3.23	6394.20	215.0
1200	200	12.0.0	19.0.0	8.4	216.85	170.2	421925.806	2550.066	44.1	3.43	7032.097	255.0
1200	200	12.0.0	22.0.0	8.4	228.13	179.1	459806.415	2949.980	44.9	3.60	7663.440	295.0
1200	200	12.0.0	25.0.0	8.4	239.41	187.9	497295.833	3349.893	45.6	3.74	8288.264	335.0
1200	200	12.0.0	28.0.0	8.4	250.69	196.8	534396.092	3749.807	46.2	3.87	8906.602	375.0
1200	200	12.0.0	32.0.0	8.4	265.73	208.6	583261.252	4283.025	46.9	4.01	9721.021	428.3
1200	200	16.0.0	25.0.0	11.2	286.50	224.9	547991.667	3372.587	43.7	3.43	9133.194	337.3



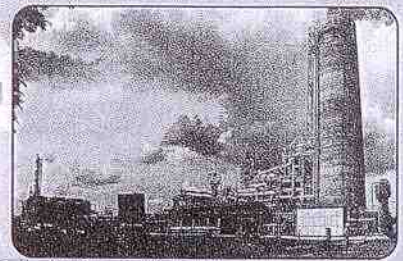
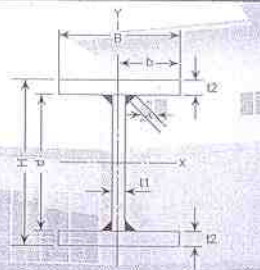
PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1200	200	16.0.0	28.0.0	11.2	297.54	233.6	584302.558	3772.382	44.3	3.56	9738.376	377.2
1200	200	16.0.0	32.0.0	11.2	312.26	245.1	632128.034	4305.442	45.0	3.71	10535.467	430.5
1200	200	16.0.0	36.0.0	11.2	326.98	256.7	679284.634	4838.502	45.6	3.85	11321.411	483.9
1200	200	16.0.0	38.0.0	11.2	334.34	262.5	702613.577	5105.033	45.8	3.91	11710.226	510.5
1200	250	9.0.0	12.0.0	6.3	166.63	130.8	333687.283	3132.144	44.7	4.34	5561.455	250.6
1200	250	9.0.0	16.0.0	6.3	185.91	145.9	399894.289	4173.762	46.4	4.74	6664.905	333.9
1200	250	9.0.0	19.0.0	6.3	200.37	157.3	448958.081	4954.976	47.3	4.97	7482.635	396.4
1200	250	9.0.0	22.0.0	6.3	215.02	168.6	497517.798	5736.189	48.1	5.17	8291.963	458.9
1200	250	9.0.0	25.0.0	6.3	229.48	180.0	545576.042	6517.403	48.8	5.33	9092.934	521.4
1200	250	12.0.0	16.0.0	8.4	221.57	173.9	439729.630	4183.486	44.5	4.35	7328.827	334.7
1200	250	12.0.0	19.0.0	8.4	235.85	185.1	488182.669	4964.649	45.5	4.59	8136.378	397.2
1200	250	12.0.0	22.0.0	8.4	250.13	196.4	536137.908	5745.813	46.3	4.79	8935.632	459.7
1200	250	12.0.0	25.0.0	8.4	264.41	207.6	583597.917	6526.977	47.0	4.97	9726.632	522.2
1200	250	12.0.0	28.0.0	8.4	278.69	218.8	630565.265	7308.140	47.6	5.12	10509.421	584.7
1200	250	12.0.0	32.0.0	8.4	297.73	233.7	692426.479	8349.692	48.2	5.30	11540.441	668.0
1200	250	16.0.0	25.0.0	11.2	311.50	244.5	634293.750	6549.670	45.1	4.59	10571.563	524.0
1200	250	16.0.0	28.0.0	11.2	325.54	255.6	680471.731	7330.715	45.7	4.75	11341.196	586.5
1200	250	16.0.0	32.0.0	11.2	344.26	270.3	741293.261	8372.109	46.4	4.93	12354.888	669.8
1200	250	16.0.0	36.0.0	11.2	362.98	284.9	801264.154	9413.502	47.0	5.09	13354.403	753.1
1200	250	16.0.0	38.0.0	11.2	372.34	292.3	830932.483	9934.199	47.2	5.17	13848.875	794.7
1200	300	9.0.0	12.0.0	6.3	178.63	140.2	376029.043	5407.144	45.9	5.50	6267.151	360.5
1200	300	9.0.0	16.0.0	6.3	201.91	158.5	455971.942	7207.096	47.5	5.97	7599.532	480.5
1200	300	9.0.0	19.0.0	6.3	219.37	172.2	515214.945	8557.059	48.5	6.25	8586.916	570.5
1200	300	9.0.0	22.0.0	6.3	237.02	185.9	573849.291	9907.023	49.2	6.47	9564.155	660.5
1200	300	9.0.0	25.0.0	6.3	254.48	199.6	631878.125	11256.986	49.8	6.65	10531.302	750.5
1200	300	12.0.0	16.0.0	8.4	237.57	186.5	495807.283	7216.819	45.7	5.51	8263.455	481.1
1200	300	12.0.0	19.0.0	8.4	254.85	200.1	554439.533	8566.733	46.6	5.80	9240.659	571.1
1200	300	12.0.0	22.0.0	8.4	272.13	213.6	612469.402	9916.646	47.4	6.04	10207.823	661.1
1200	300	12.0.0	25.0.0	8.4	289.41	227.2	669900.0	11266.560	48.1	6.24	11165.0	751.1
1200	300	12.0.0	28.0.0	8.4	306.69	240.8	726734.438	12616.474	48.7	6.41	12112.241	841.1
1200	300	12.0.0	32.0.0	8.4	329.73	258.8	801591.706	14416.358	49.3	6.61	13359.862	961.1
1200	300	16.0.0	25.0.0	11.2	336.50	264.2	720595.833	11289.253	46.3	5.79	12009.931	752.6
1200	300	16.0.0	28.0.0	11.2	353.54	277.5	776640.905	12639.049	46.9	5.98	12944.015	842.6
1200	300	16.0.0	32.0.0	11.2	376.26	295.4	850458.487	14438.775	47.5	6.19	14174.308	962.6
1200	300	16.0.0	36.0.0	11.2	398.98	313.2	923243.674	16238.502	48.1	6.38	15387.395	1082.6
1200	300	16.0.0	38.0.0	11.2	410.34	322.1	959251.390	17138.366	48.3	6.46	15987.523	1142.6

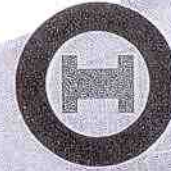
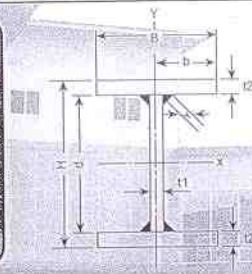
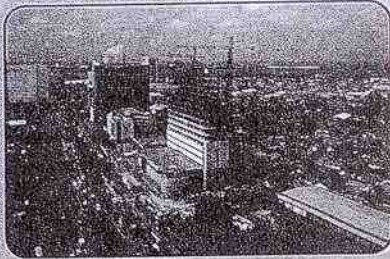


PT CIGADING HABEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1200	350	9.0.0	12.0.0	6.3	190.63	149.6	418370.803	8582.144	46.8	6.71	6972.847	490.4
1200	350	9.0.0	16.0.0	6.3	217.91	171.1	512049.596	11440.429	48.5	7.25	8534.160	653.7
1200	350	9.0.0	19.0.0	6.3	238.37	187.1	581471.808	13584.142	49.4	7.55	9691.197	776.2
1200	350	9.0.0	22.0.0	6.3	259.02	203.2	650180.785	15727.856	50.1	7.80	10836.346	898.7
1200	350	9.0.0	25.0.0	6.3	279.48	219.2	718180.208	17871.570	50.7	8.00	11969.670	1021.2
1200	350	12.0.0	16.0.0	8.4	253.57	199.1	551884.937	11450.153	46.7	6.72	9198.082	654.3
1200	350	12.0.0	19.0.0	8.4	273.85	215.0	620696.396	13593.816	47.6	7.05	10344.940	776.8
1200	350	12.0.0	22.0.0	8.4	294.13	230.9	688800.895	15737.480	48.4	7.31	11480.015	899.3
1200	350	12.0.0	25.0.0	8.4	314.41	246.8	756202.083	17881.143	49.0	7.54	12603.368	1021.8
1200	350	12.0.0	28.0.0	8.4	334.69	262.7	822903.612	20024.807	49.6	7.74	13715.060	1144.3
1200	350	12.0.0	32.0.0	8.4	361.73	284.0	910756.932	22883.025	50.2	7.95	15179.282	1307.6
1200	350	16.0.0	25.0.0	11.2	361.50	283.8	806897.917	17903.837	47.2	7.04	13448.299	1023.1
1200	350	16.0.0	28.0.0	11.2	381.26	299.5	872810.078	20047.382	47.8	7.25	14546.835	1145.6
1200	350	16.0.0	32.0.0	11.2	408.26	320.5	959623.714	22905.442	48.5	7.49	15993.729	1308.9
1200	350	16.0.0	36.0.0	11.2	434.98	341.5	1045223.194	25763.502	49.0	7.70	17420.387	1472.2
1200	350	16.0.0	38.0.0	11.2	448.34	352.0	1087570.297	27192.533	49.3	7.79	18126.172	1553.9
1200	400	9.0.0	12.0.0	6.3	202.63	159.1	460712.563	12807.144	47.7	7.95	7678.543	640.4
1200	400	9.0.0	16.0.0	6.3	233.91	183.6	568127.249	17073.762	49.3	8.54	9468.787	853.7
1200	400	9.0.0	19.0.0	6.3	257.37	202.0	647728.671	20273.726	50.2	8.88	10795.478	1013.7
1200	400	9.0.0	22.0.0	6.3	280.02	220.5	726512.278	23473.689	50.9	9.14	12108.538	1173.7
1200	400	9.0.0	25.0.0	6.3	304.48	238.9	804482.292	26673.653	51.4	9.36	13408.038	1333.7
1200	400	12.0.0	16.0.0	8.4	269.57	211.6	607962.590	17083.486	47.5	7.96	10132.710	854.2
1200	400	12.0.0	19.0.0	8.4	292.85	229.9	686953.259	20283.399	48.4	8.32	11449.221	1014.2
1200	400	12.0.0	22.0.0	8.4	316.13	248.2	765132.388	23483.313	49.2	8.62	12752.206	1174.2
1200	400	12.0.0	25.0.0	8.4	339.41	266.4	842504.167	26683.227	49.8	8.87	14041.736	1334.2
1200	400	12.0.0	28.0.0	8.4	362.69	284.7	919072.785	29883.140	50.3	9.08	15317.880	1494.2
1200	400	12.0.0	32.0.0	8.4	393.73	309.1	1019922.159	34149.692	50.9	9.31	16998.703	1707.5
1200	400	16.0.0	25.0.0	11.2	386.50	303.4	893200.0	26705.920	48.1	8.31	14886.667	1335.3
1200	400	16.0.0	28.0.0	11.2	409.54	321.5	968979.251	29905.715	48.6	8.55	16149.654	1495.3
1200	400	16.0.0	32.0.0	11.2	440.26	345.6	1068788.941	34172.109	49.3	8.81	17813.149	1708.6
1200	400	16.0.0	36.0.0	11.2	470.98	369.7	1167202.714	38438.502	49.8	9.03	19453.379	1921.9
1200	400	16.0.0	38.0.0	11.2	486.34	381.8	1215889.203	40571.699	50.0	9.13	20264.820	2028.6
1200	450	9.0.0	12.0.0	6.3	214.63	168.5	503054.323	18232.144	48.4	9.22	8384.239	810.3
1200	450	9.0.0	16.0.0	6.3	249.91	196.2	624204.902	24307.096	50.0	9.86	10403.415	1080.3
1200	450	9.0.0	19.0.0	6.3	276.37	217.0	713985.535	28863.309	50.8	10.22	11899.759	1282.8
1200	450	9.0.0	22.0.0	6.3	303.02	237.7	802843.771	33419.523	51.5	10.51	13380.730	1485.3
1200	450	9.0.0	25.0.0	6.3	329.48	258.5	890784.375	37975.736	52.0	10.74	14846.406	1687.8
1200	450	12.0.0	16.0.0	8.4	285.57	224.2	664040.243	24316.819	48.2	9.23	11067.337	1080.7



PT CIGADING HABEAM CENTRE

UKURAN DAN SIFAT-SIFAT PENAMPANG

SIZE OF H-BEAM (mm)					AREA OF SECTION (cm ²)	WEIGHT PER METER (kg/m)	Inertia Moment		Gyration Radius		Section Modulus	
DEPTH	WIDTH	t WEB	t FLANGE	L. L			Ix	Iy	ix	iy	Zx	Zy
H	B	t1	t2	S			(cm ⁴)	(cm ⁴)	(cm)	(cm)	(cm ³)	(cm ³)
1150	300	9.0.0	12.0.0	6.3	174.13	136.7	340188.688	5406.840	44.2	5.57	5916.325	360.5
1150	300	9.0.0	16.0.0	6.3	197.41	155.0	413456.047	7206.792	45.8	6.04	7190.540	480.5
1150	300	9.0.0	19.0.0	6.3	214.87	168.7	467722.950	8556.755	46.7	6.31	8134.312	570.5
1150	300	9.0.0	22.0.0	6.3	232.52	182.4	521407.386	9906.719	47.4	6.53	9067.955	660.4
1150	300	9.0.0	25.0.0	6.3	249.98	196.1	574512.50	11256.683	48.0	6.71	9991.522	750.4
1150	300	12.0.0	16.0.0	8.4	231.57	181.8	448391.423	7216.099	44.0	5.58	7798.112	481.1
1150	300	12.0.0	19.0.0	8.4	248.85	195.3	502098.873	8566.013	44.9	5.87	8732.154	571.1
1150	300	12.0.0	22.0.0	8.4	266.13	208.9	555229.862	9915.926	45.7	6.10	9656.172	661.1
1150	300	12.0.0	25.0.0	8.4	283.41	222.5	607787.50	11265.840	46.3	6.30	10570.217	751.1
1150	300	12.0.0	28.0.0	8.4	300.69	236.0	659774.898	12615.754	46.8	6.48	11474.346	841.1

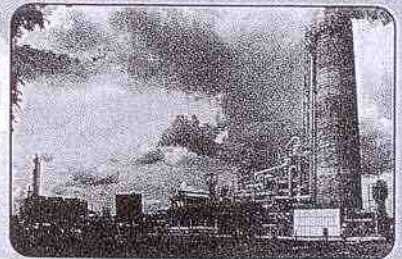
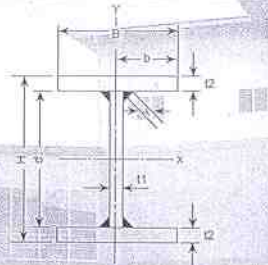
**SCOPE OF PRODUCTION
Lingkup Produksi**

On Line : H = 200 mm - 1200 mm
B = 100 mm - 500 mm
t1 = 5 mm - 25 mm
t2 = 8 mm - 25 mm

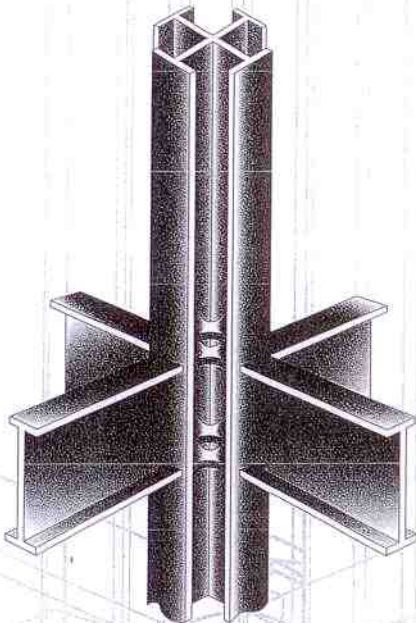
Special Size : H = 1200 mm - 2800 mm
B = 500 mm - 800 mm
t1 = 25 mm - 100 mm
t2 = 25 mm - 100 mm



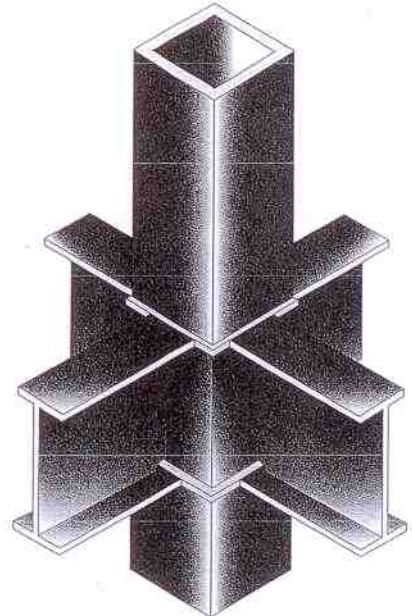
PT CIGADING HAKEAM CENTRE



UKURAN DAN SIFAT-SIFAT PENAMPANG

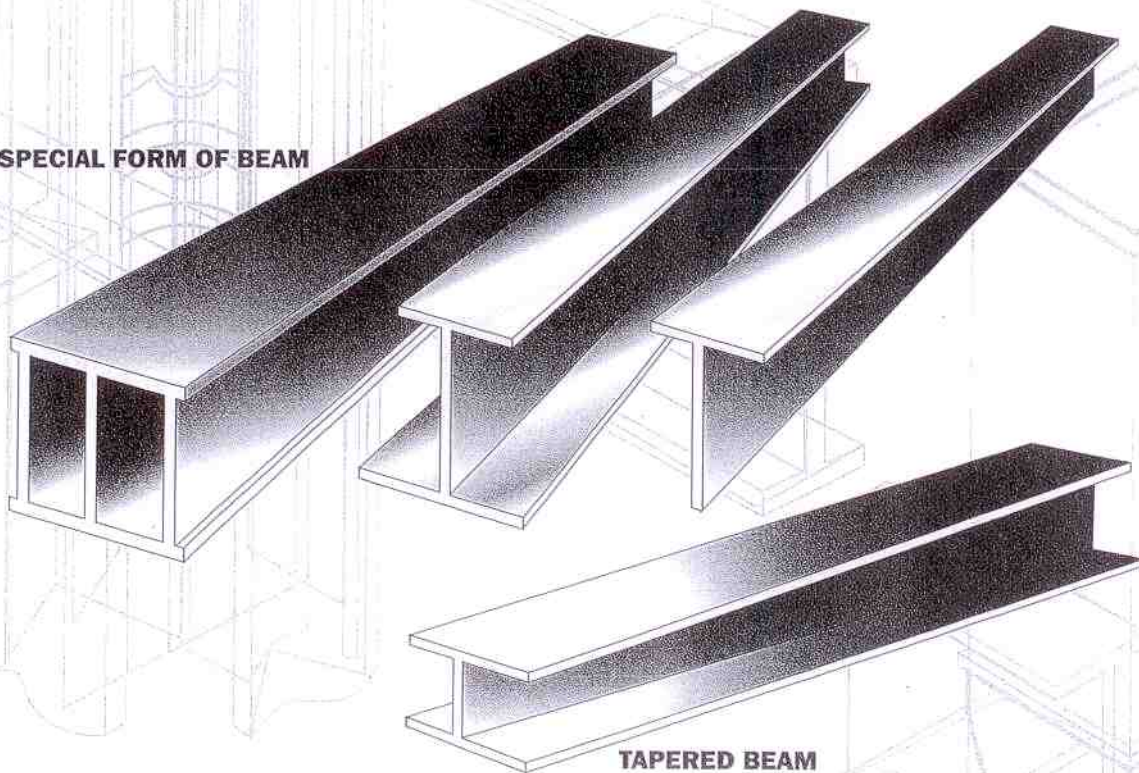


**WELDED
CROSS COLUMN**



WELDED BOX COLUMN

SPECIAL FORM OF BEAM



TAPERED BEAM

MEMO

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN MEMANJANG EKSISTING
- POTONGAN MEMANJANG RENCANA

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

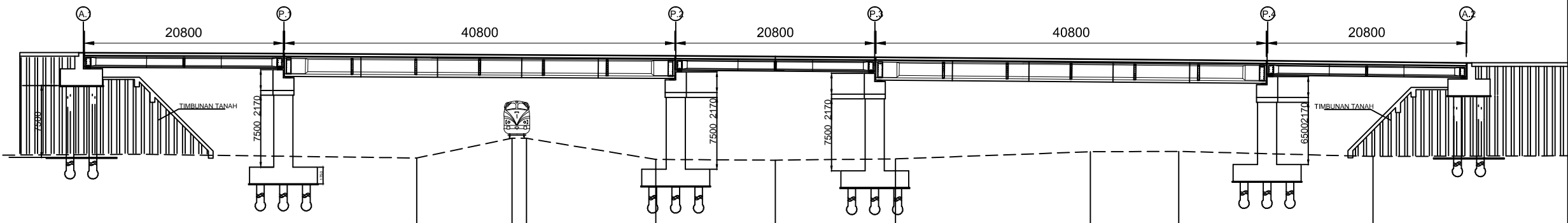
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

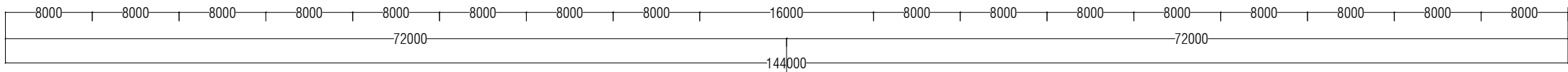
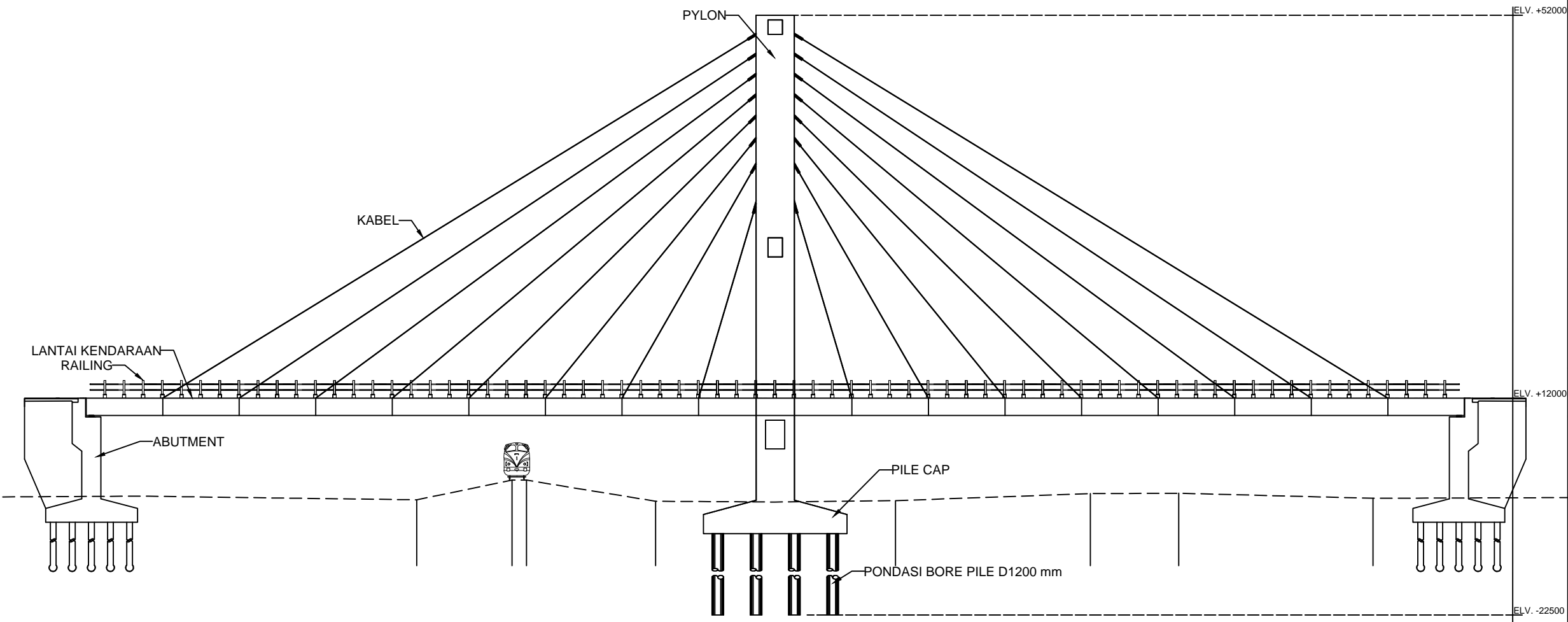
1

JUMLAH

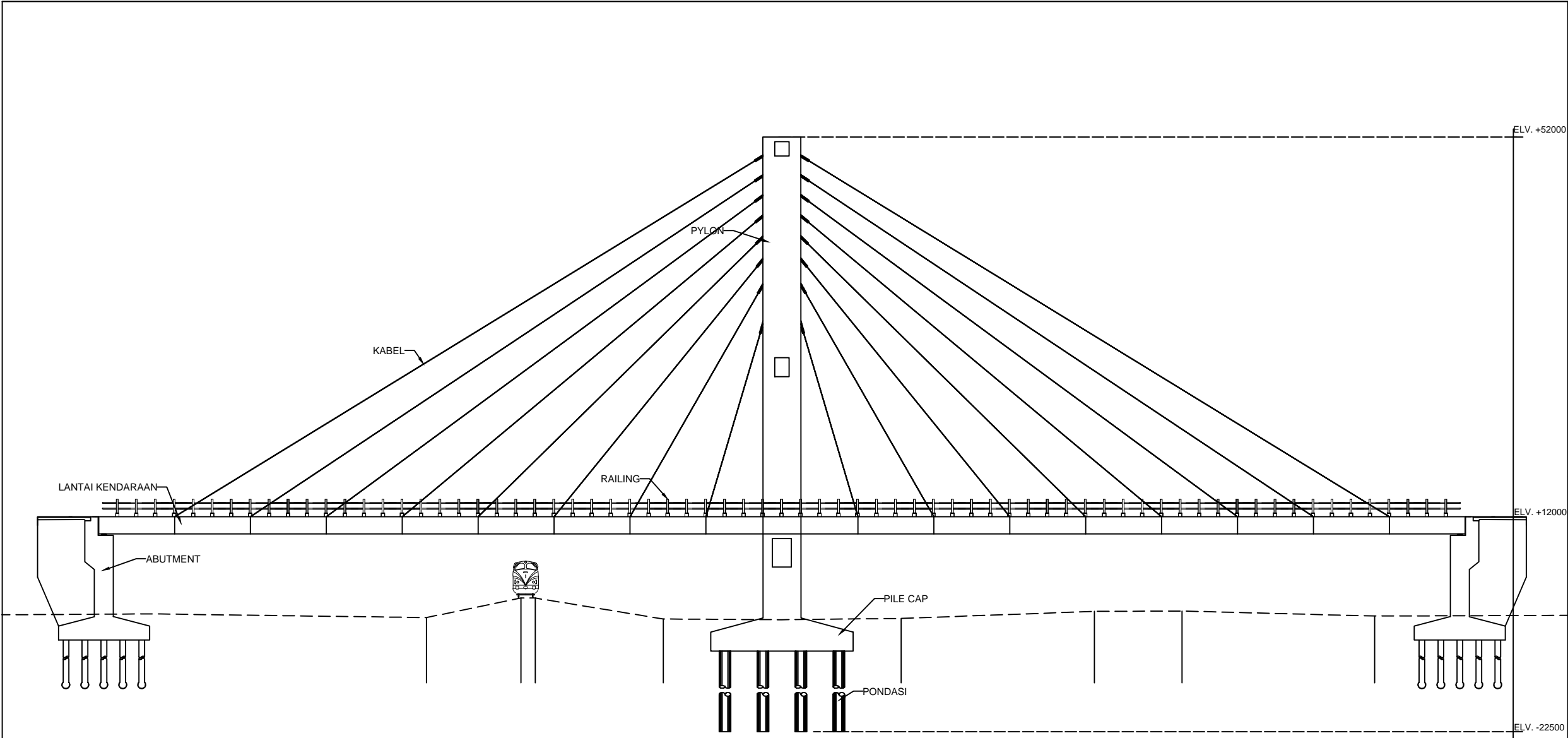
30



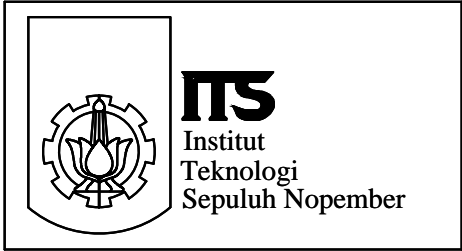
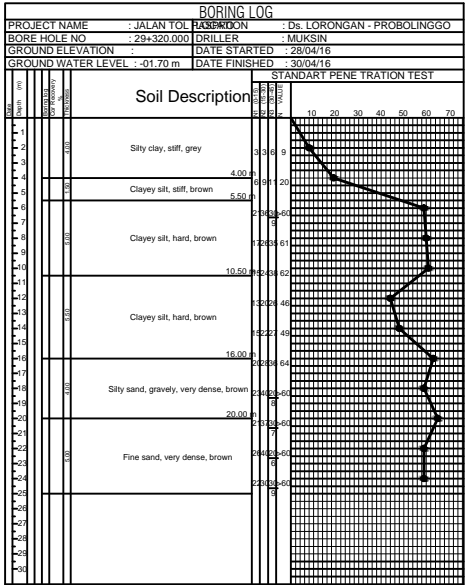
POTONGAN MEMANJANG EKSISTING
SKALA 1:500



POTONGAN MEMANJANG RENCANA
SKALA 1:500



DATA SPT TANAH LOKASI PROYEK
SKALA 1:500



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- DATA SPT TANAH PROYEK

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

2

30

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLNGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAMPAK ATAS JEMBATAN
- DETAIL A

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

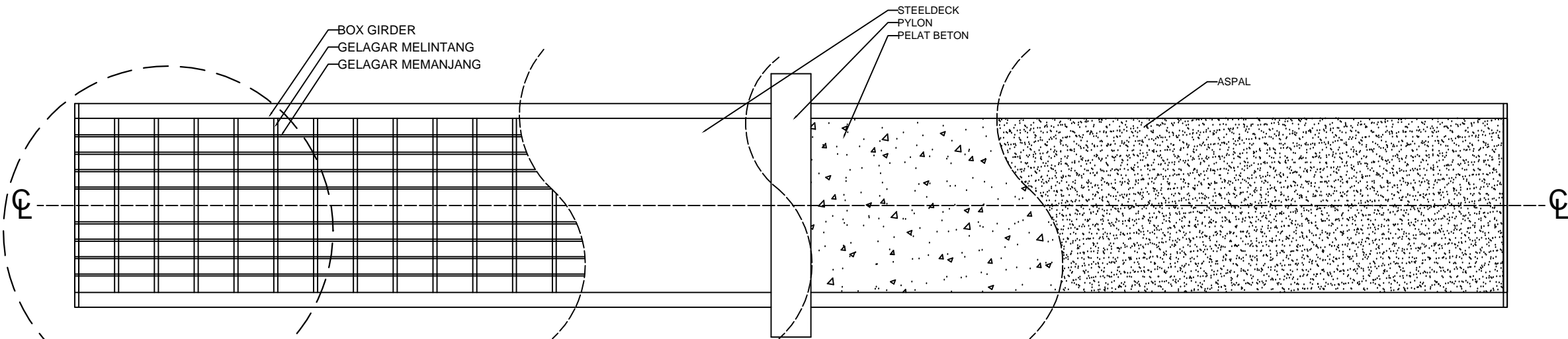
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

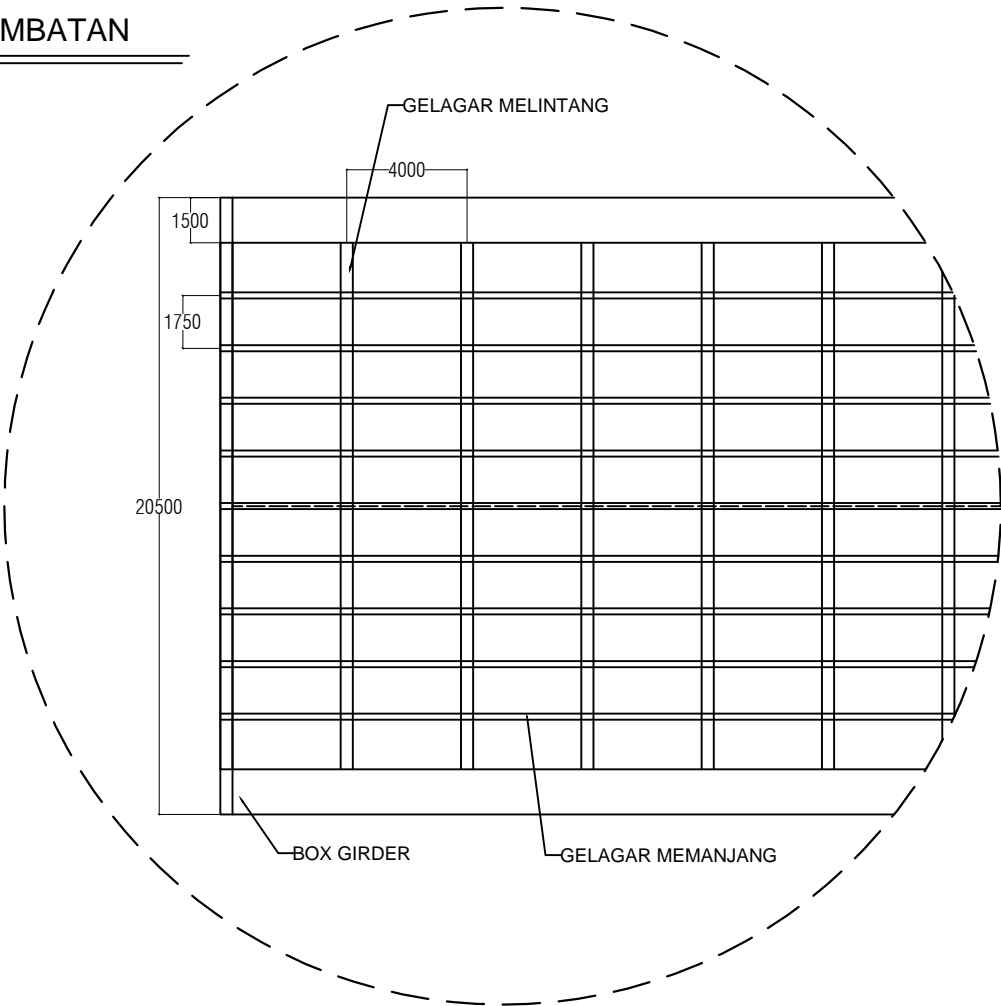
3

30



DETAIL A

TAMPAK ATAS JEMBATAN
SKALA 1:500



DETAIL A
SKALA 1:250

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- LAYOUT PEMBAGIAN
SEGMENT

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

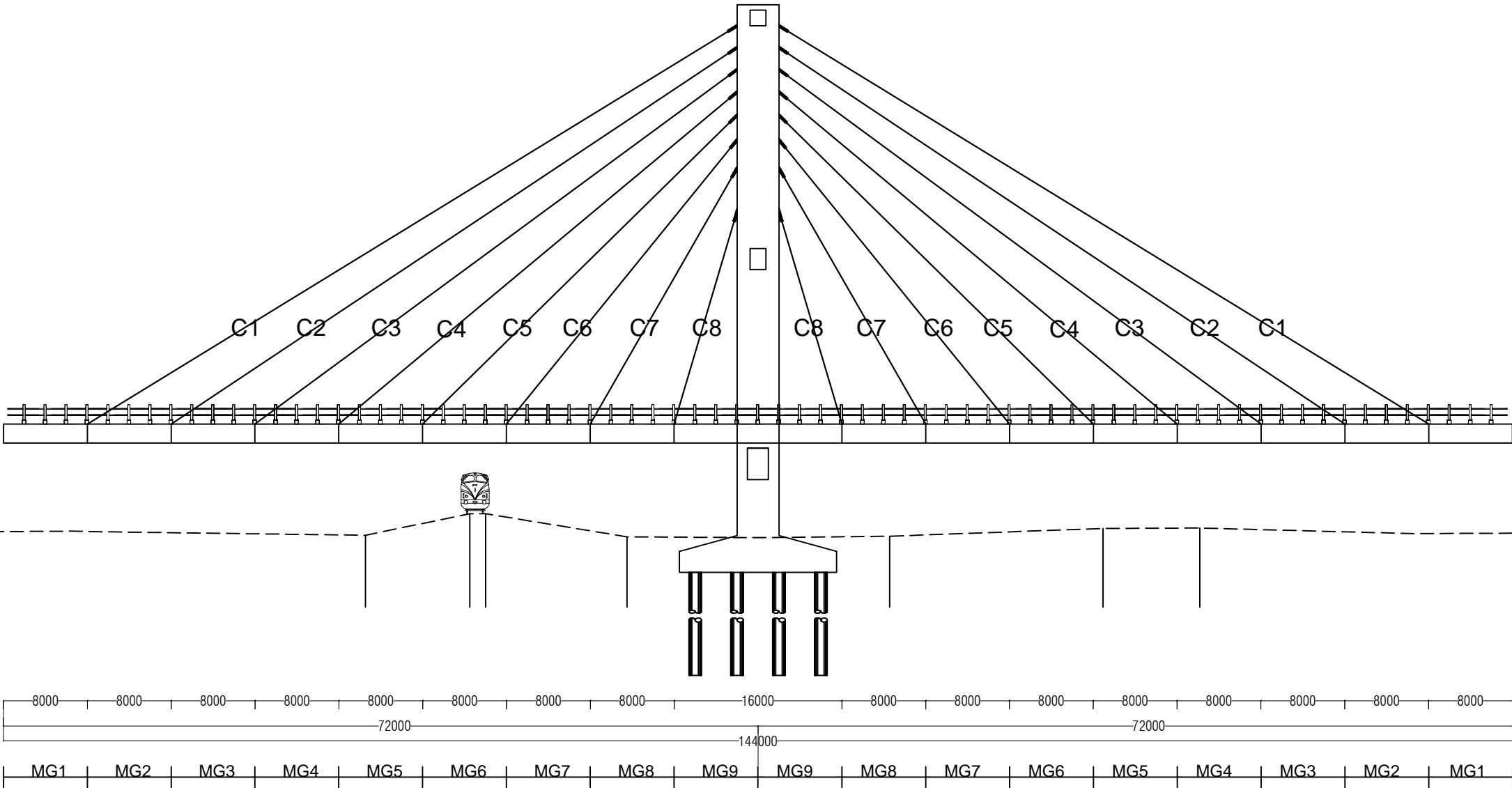
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

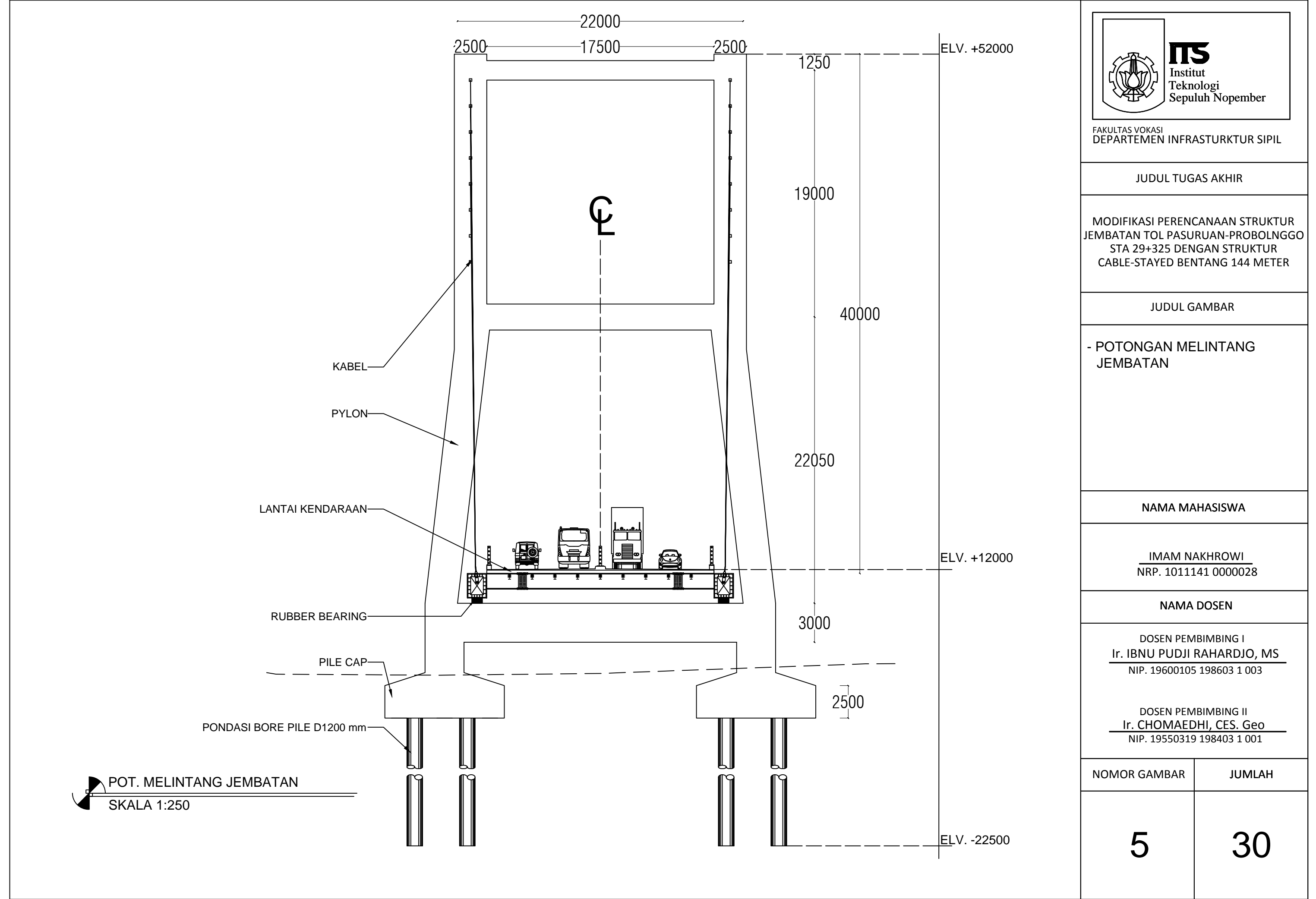
JUMLAH

4

30



LAYOUT PEMBAGIAN SEGMENT
SKALA 1:500



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN MELINTANG
JEMBATAN

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

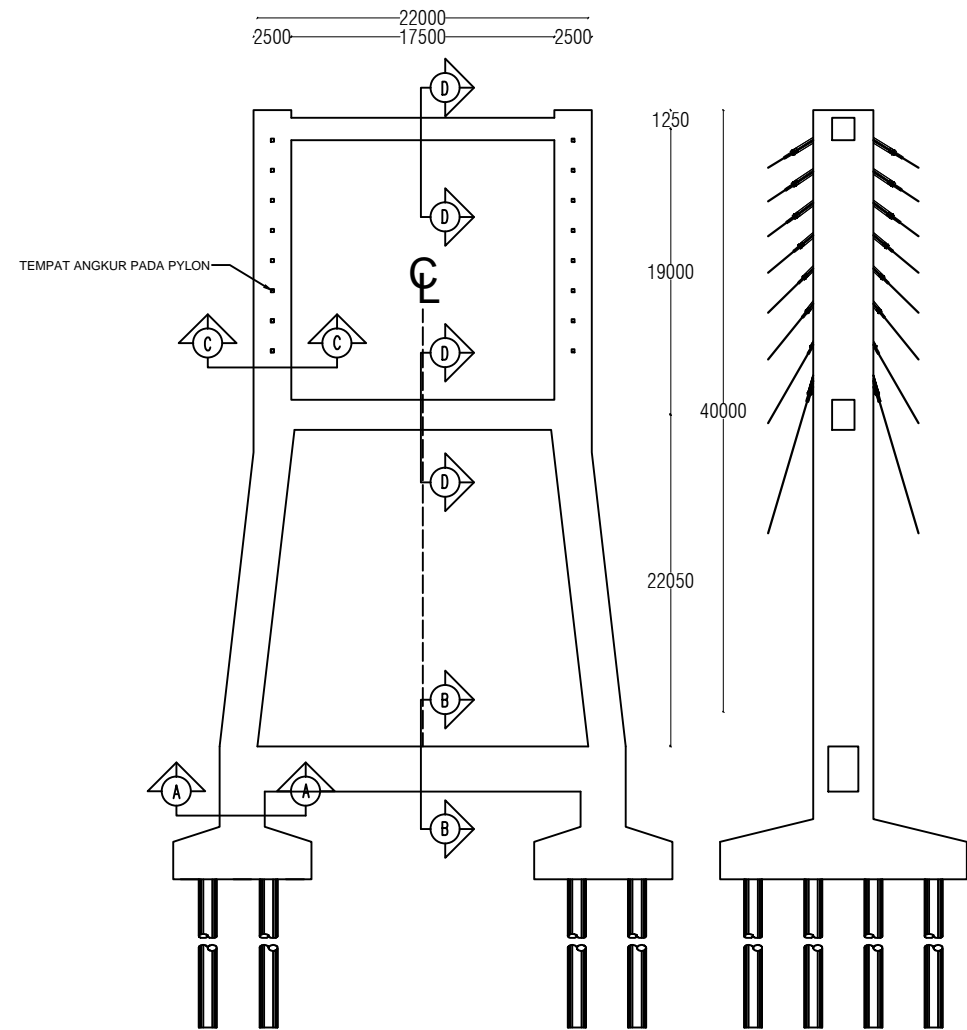
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

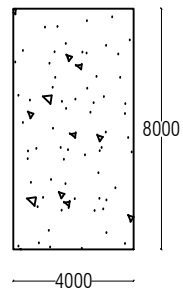
JUMLAH


5

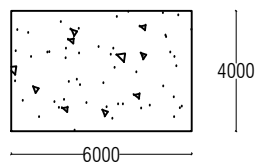
30



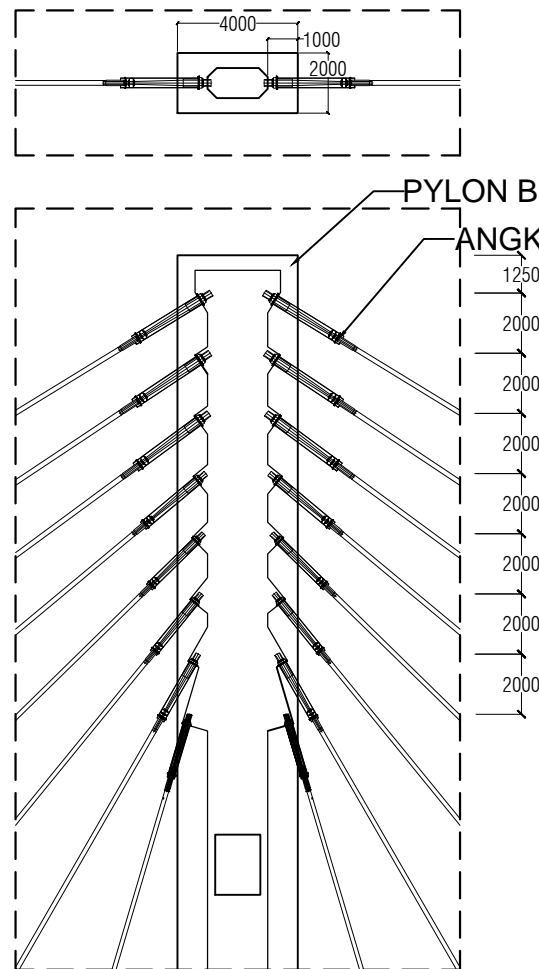
 POT. MELINTANG PYLON
SKALA 1:500




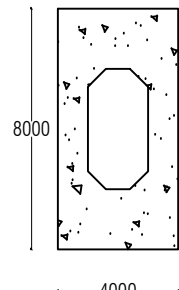
 POTONGAN A-A
SKALA 1:250




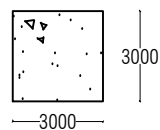
 POTONGAN B-B
SKALA 1:250



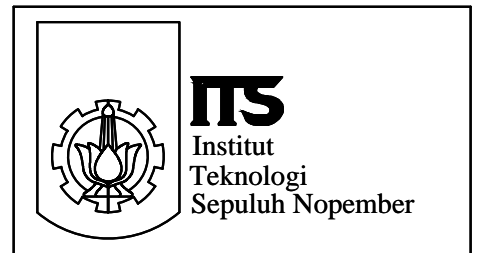
 DETAIL ANGKUR PADA PYLON
SKALA 1:250



 POTONGAN C-C
SKALA 1:250



 POTONGAN D-D
SKALA 1:250



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN MELINTANG PYLON
- DETAIL ANGKUR PADA PYLON
- POTONGAN A-A
- POTONGAN B-B
- POTONGAN C-C
- POTONGAN D-D

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

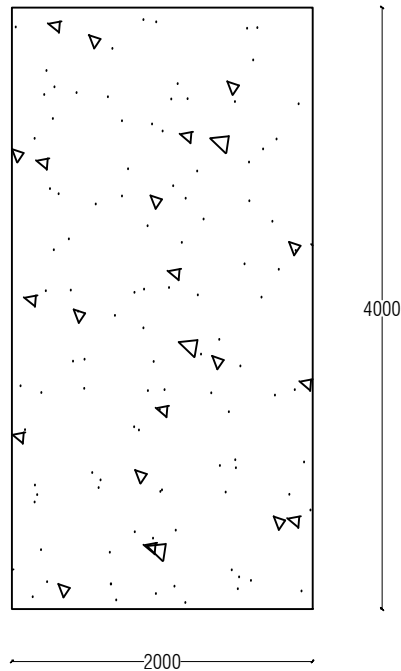
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

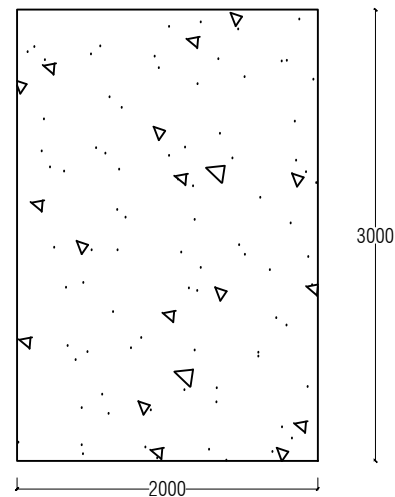
6

JUMLAH

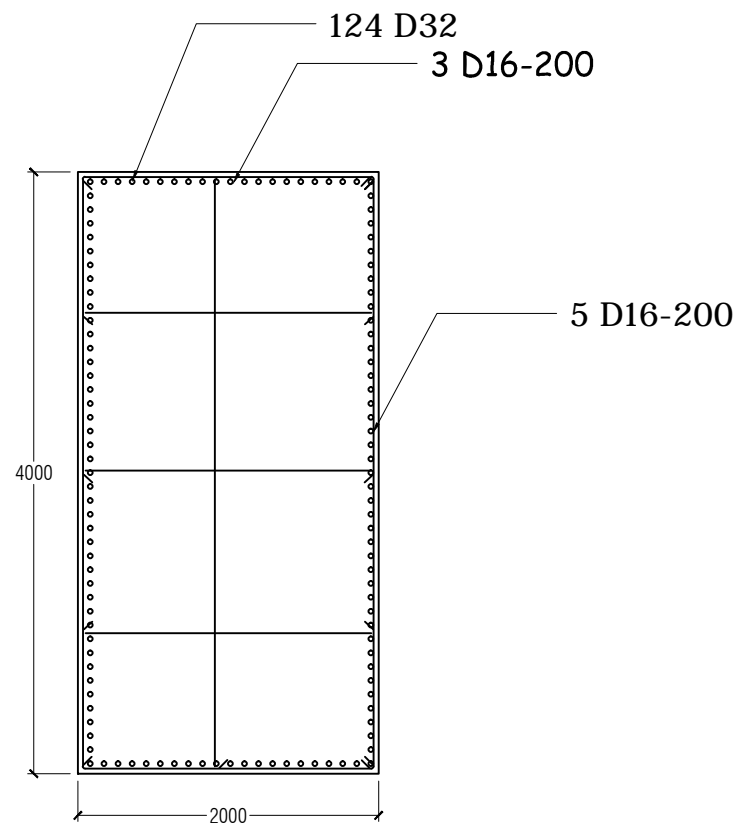
30



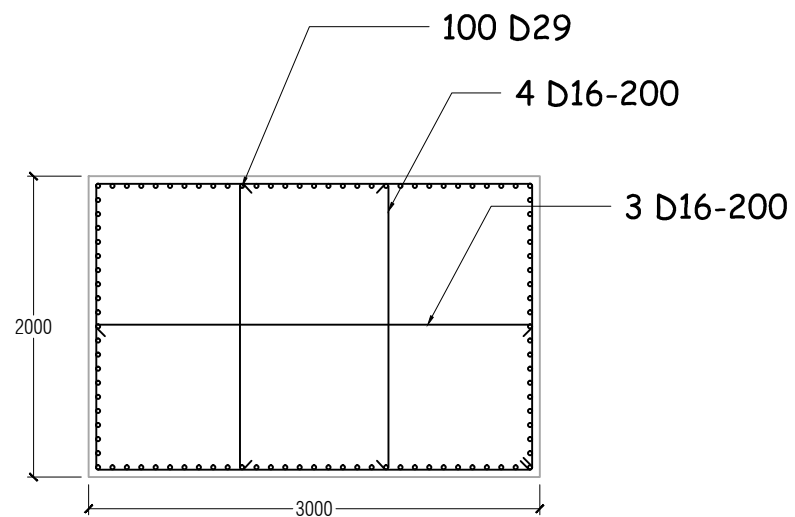
POTONGAN A-A
SKALA 1:100



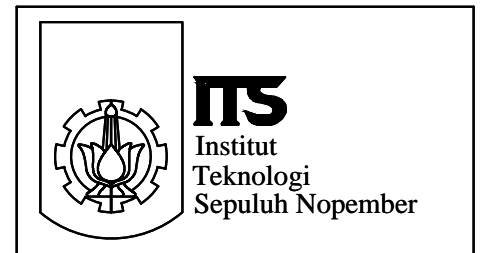
POTONGAN B-B
SKALA 1:100



PENULANGAN POT. AA
SKALA 1:100



PENULANGAN POT B-B
SKALA 1:100



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLNGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN A-A
- POTONGAN B-B
- PENULANGAN A-A
- PENULANGAN B-B

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

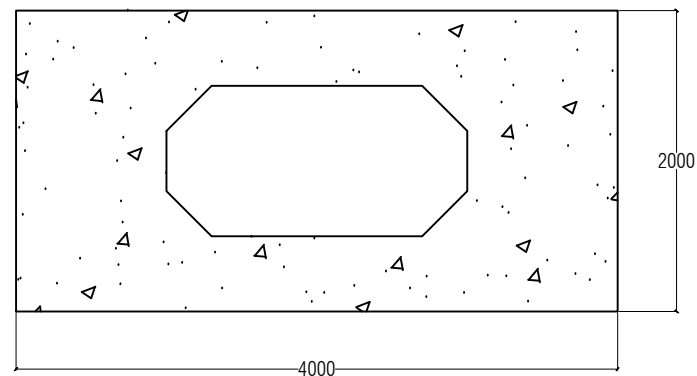
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001


NOMOR GAMBAR

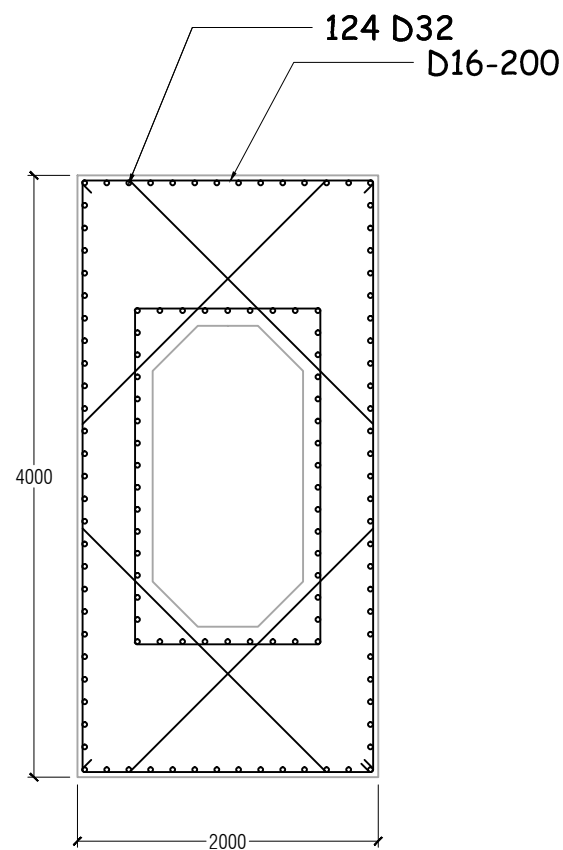
JUMLAH

7

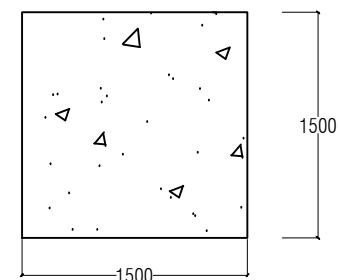
30




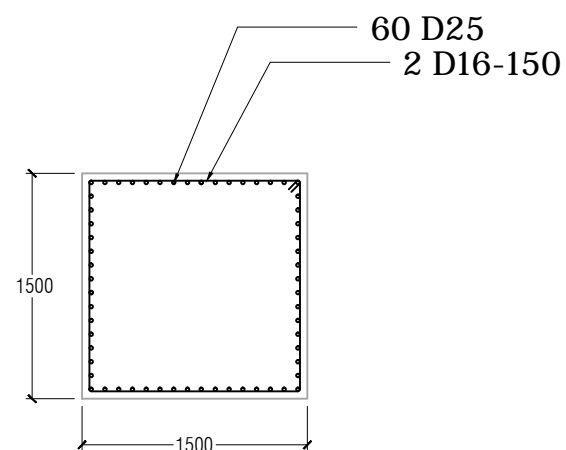
 **POTONGAN C-C**
SKALA 1:100




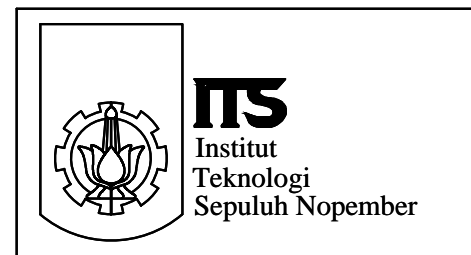
 **PENULANGAN POT C-C**
SKALA 1:100



 **POTONGAN D-D**
SKALA 1:100



 **PENULANGAN POT D-D**
SKALA 1:100



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN C-C
- POTONGAN D-D
- PENULANGAN C-C
- PENULANGAN D-D

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

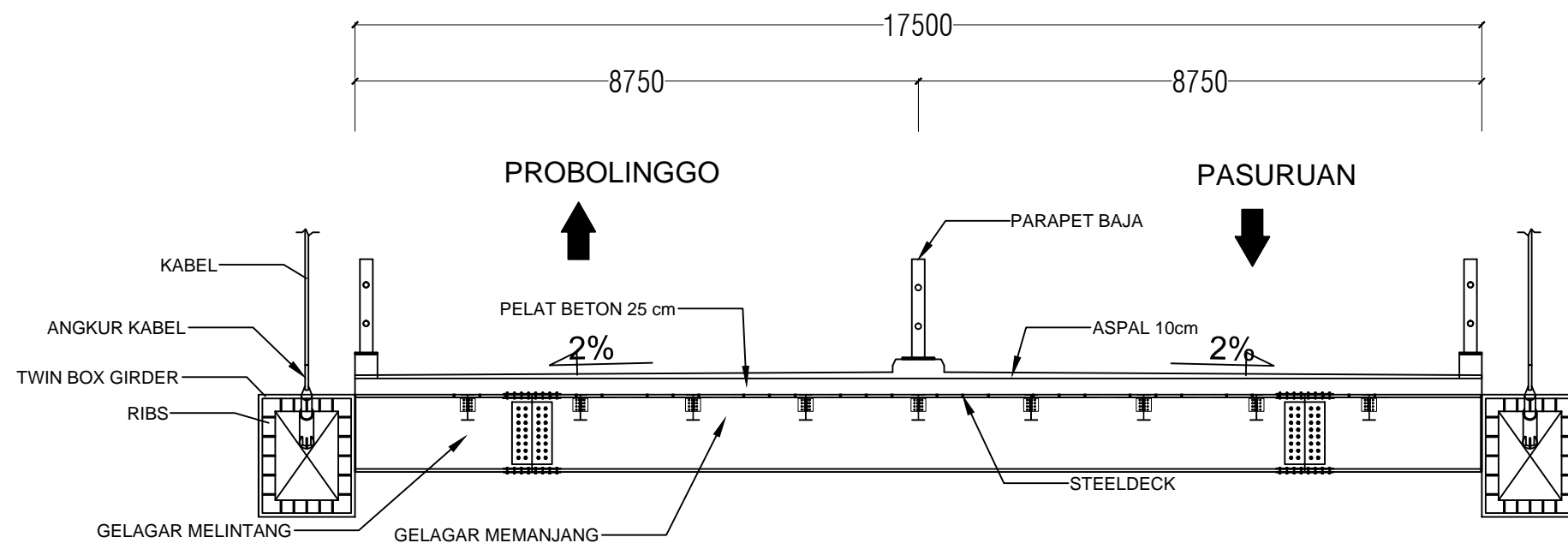
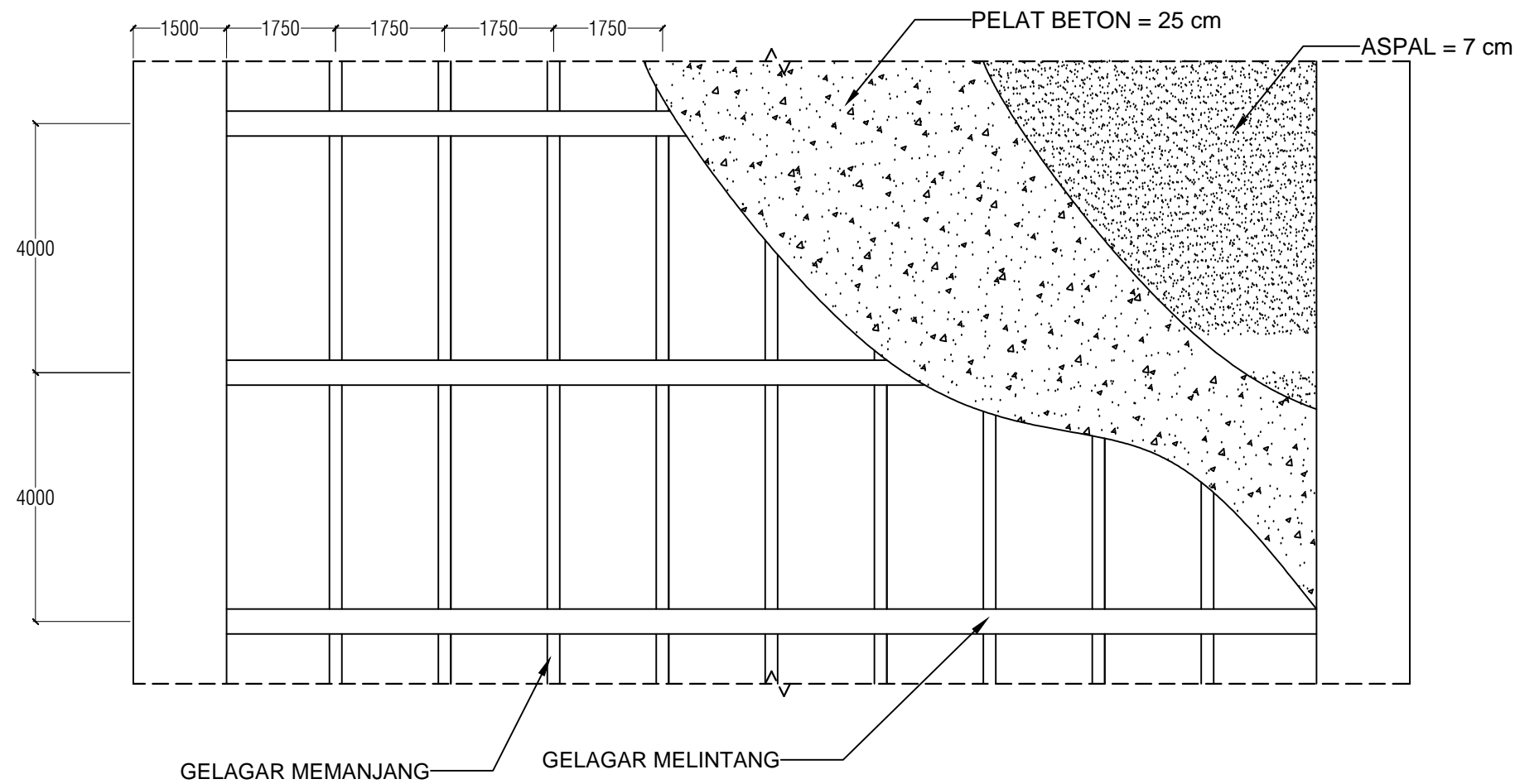
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

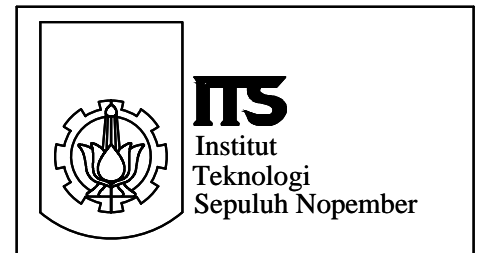
JUMLAH

8

30



POT. MELINTANG LANTAI KENDARAAN
SKALA 1:100



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN MELINTANG
LANTAI KENDARAAN

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

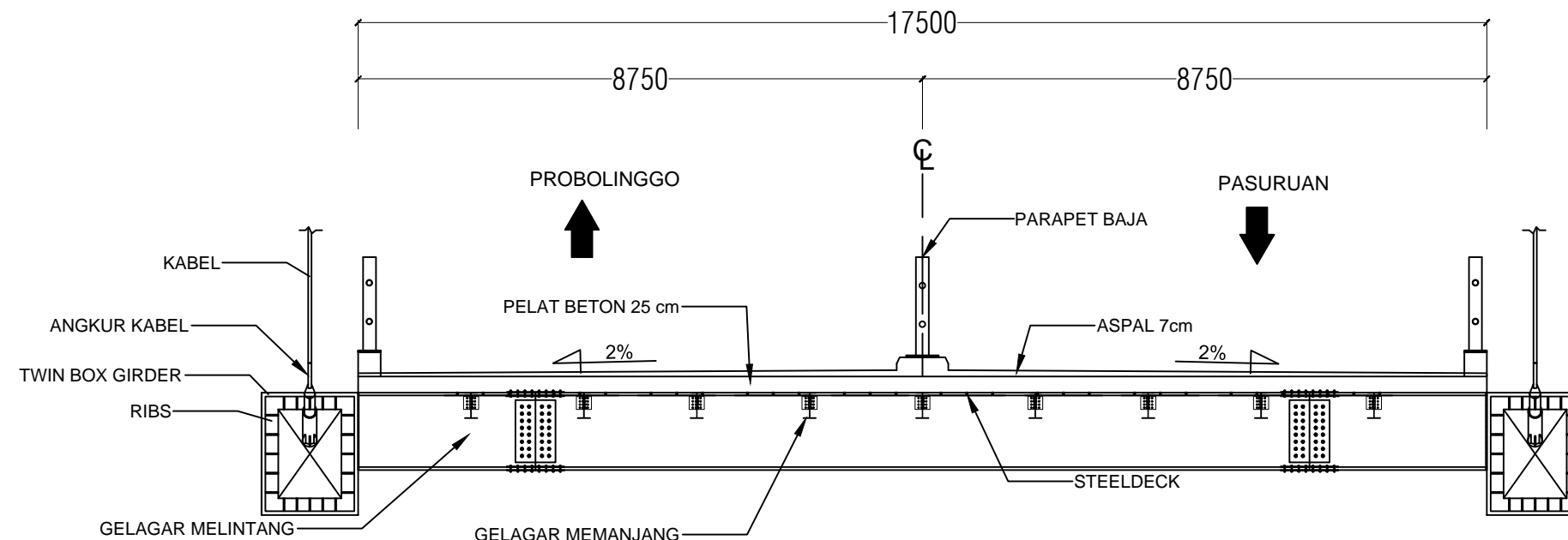
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

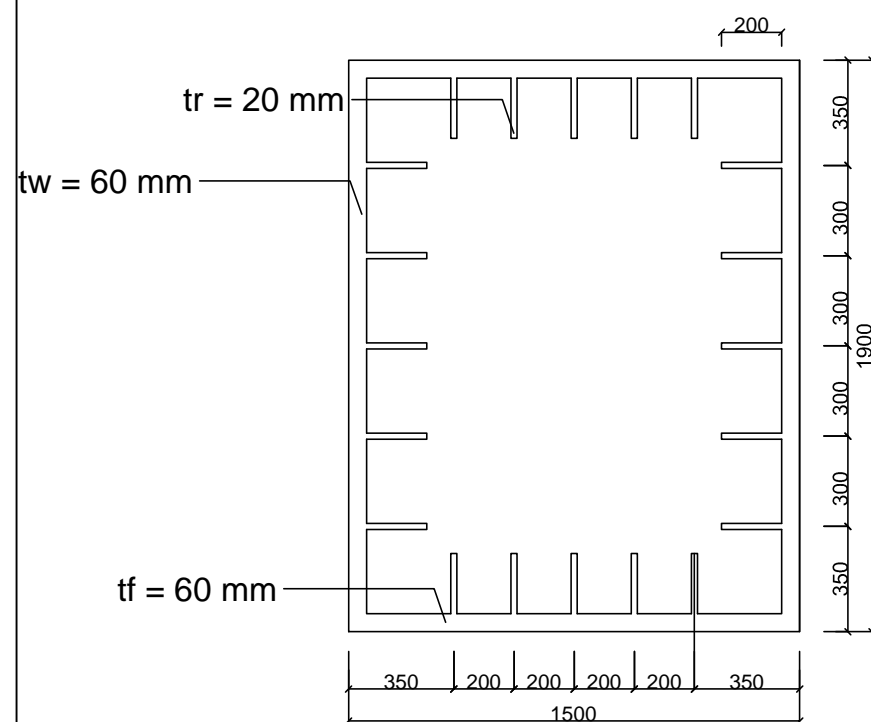
9

JUMLAH

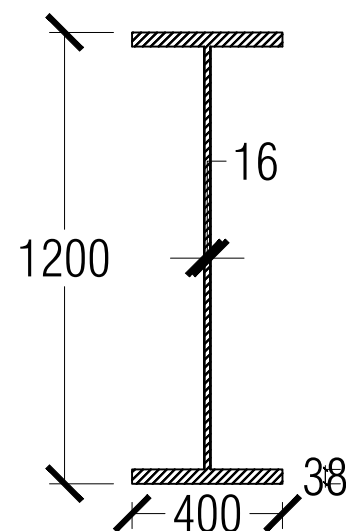
30



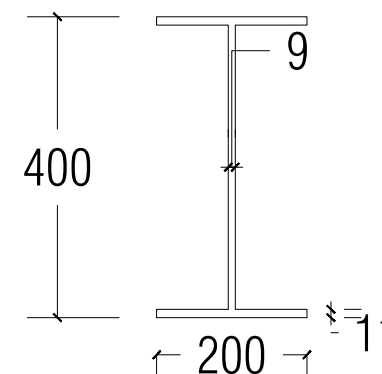
POT. MELINTANG LANTAI KENDARAAN
SKALA 1:100



DETAIL BOX
SKALA 1:25



PENAMPANG GEL. MELINTANG
SKALA 1:20



PENAMPANG GEL. MEMANJANG
SKALA 1:10



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- POTONGAN MELINTANG LANTAI KENDARAAN
- DETAIL BOX
- PENAMPANG GELAGAR MELINTANG
- PENAMPANG GELAGAR MEMANJANG

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

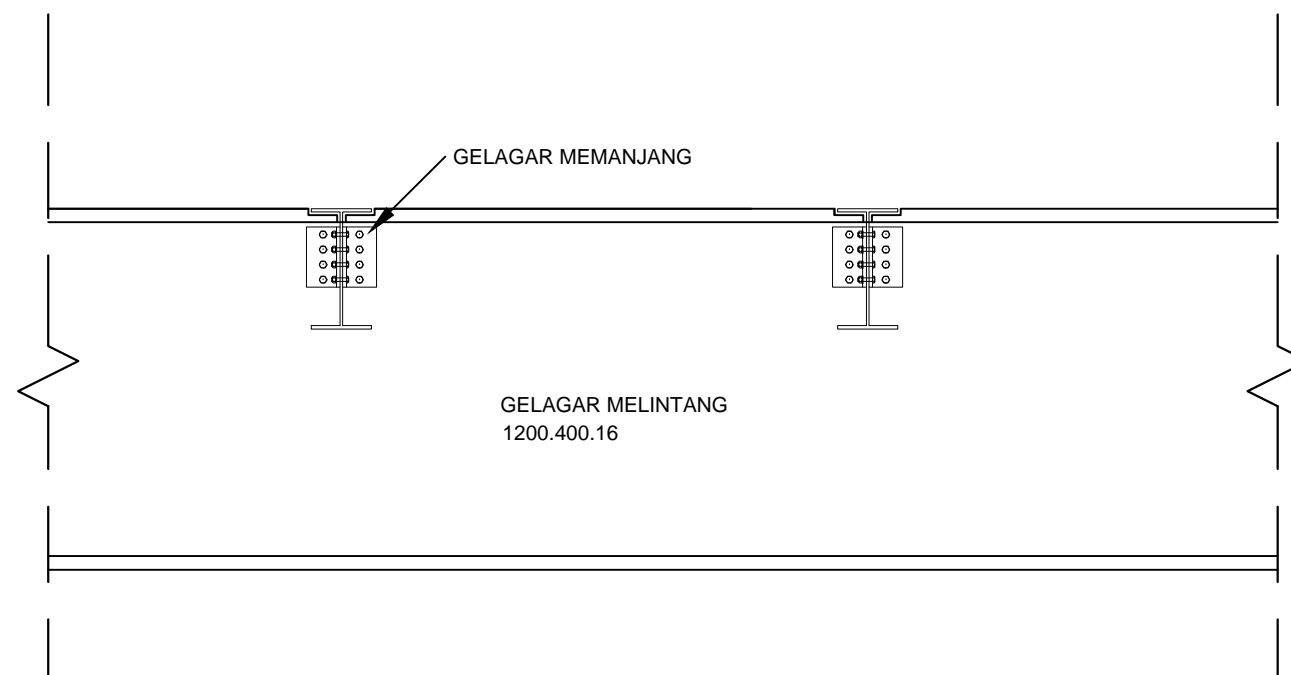
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

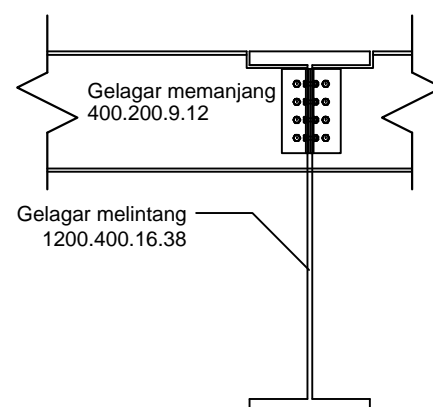
10

JUMLAH

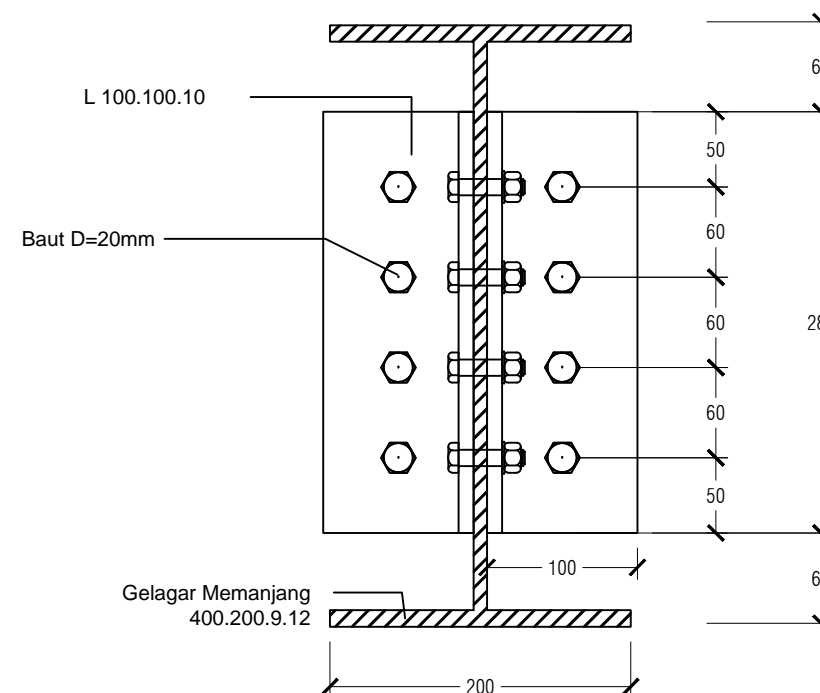
30



SAMBUNGAN GELAGAR MEMANJANG KE MELINTANG
SKALA 1:25



TAMPAK SAMPING SAMBUNGAN GELAGAR MEMANJANG
SKALA 1:25



DETAIL SAMBUNGAN GELAGAR MEMANJANG
SKALA 1:5



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLNGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- SAMBUNGAN GELAGAR
MEMANJANG KE MELINTANG
- TAMPAK SAMPING
- DETAIL SAMBUNGAN

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

11

30

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
 JEMBATAN TOL PASURUAN-PROBOLNGGO
 STA 29+325 DENGAN STRUKTUR
 CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- SAMBUNGAN GELAGAR
 MELINTANG KE UTAMA
 - SAMBUNGAN ANTAR
 GELAGAR MELINTANG

NAMA MAHASISWA

IMAM NAKHROWI
 NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
 Ir. IBNU PUDJI RAHARDJO, MS
 NIP. 19600105 198603 1 003

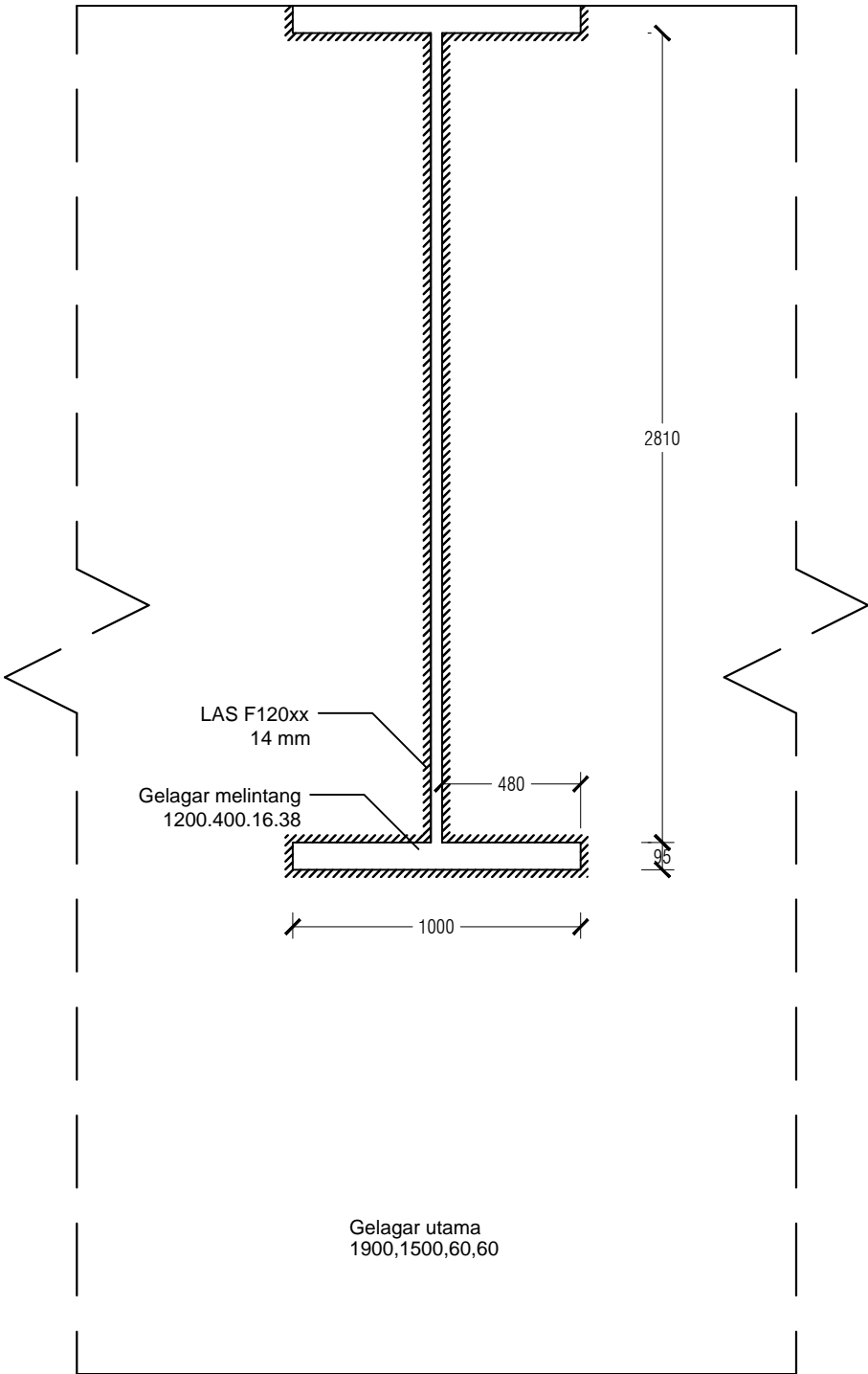
DOSEN PEMBIMBING II
 Ir. CHOMAEDHI, CES. Geo
 NIP. 19550319 198403 1 001

NOMOR GAMBAR

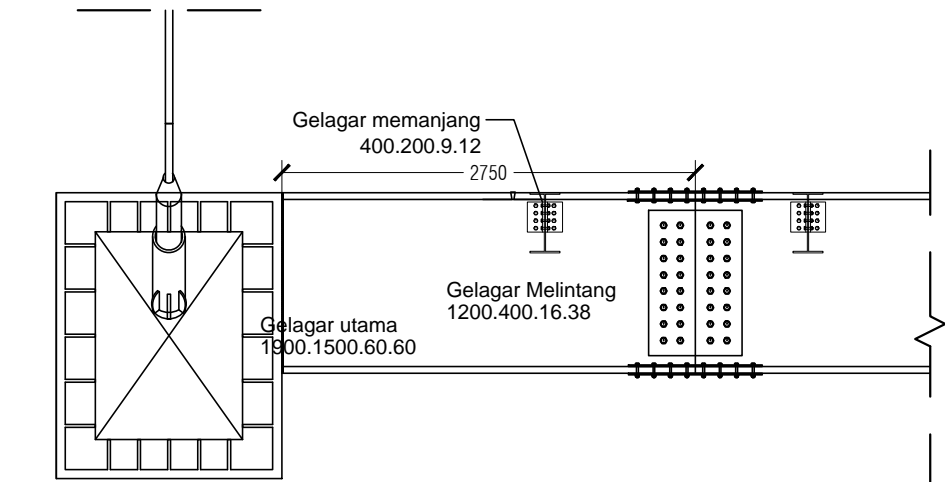
JUMLAH

12

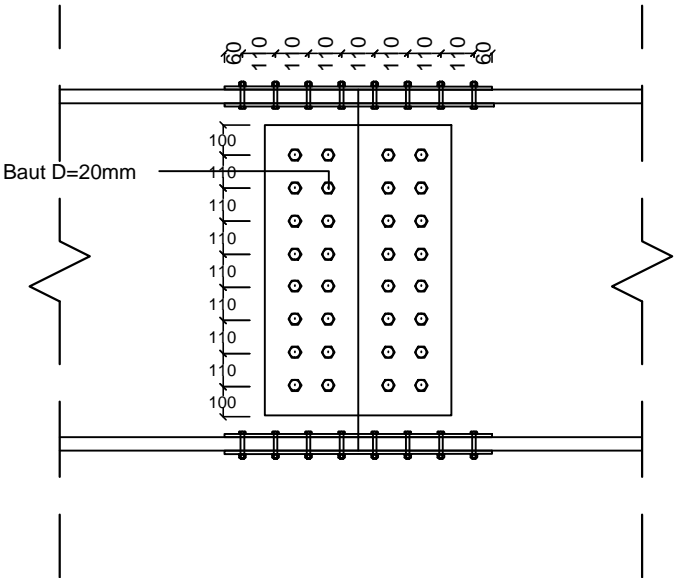
30



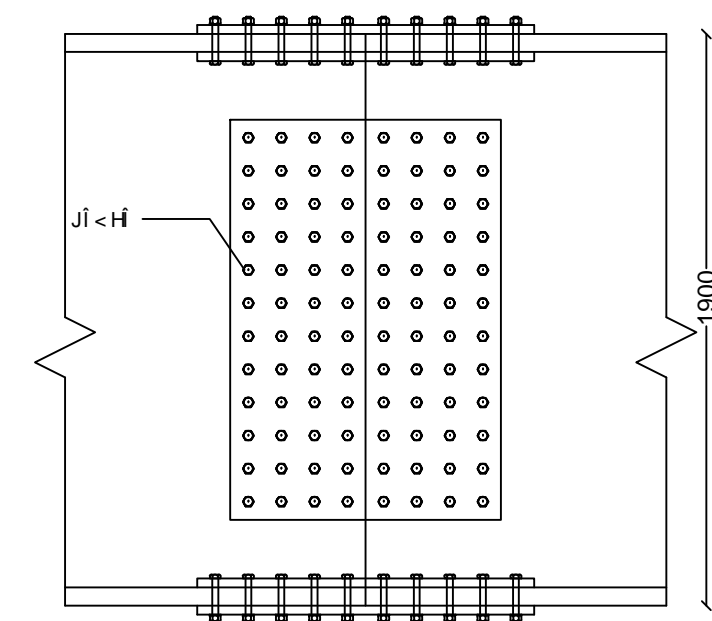

 SAMBUNGAN LAS GELAGAR MELINTANG
 SKALA 1:10



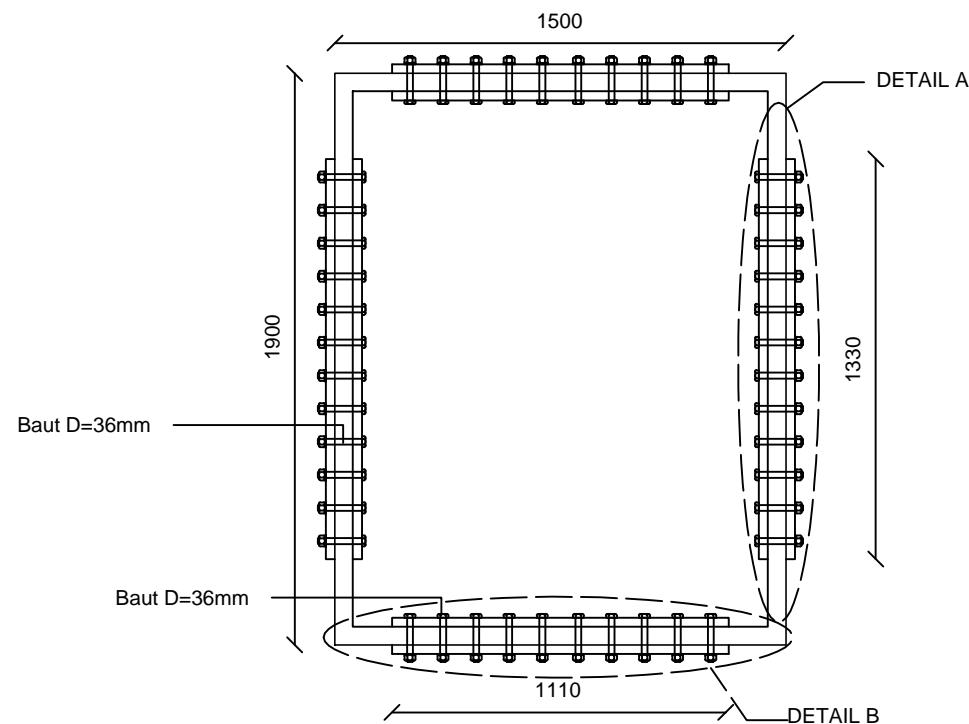

 SAMBUNGAN GELAGAR MELINTANG KE UTAMA
 SKALA 1:25



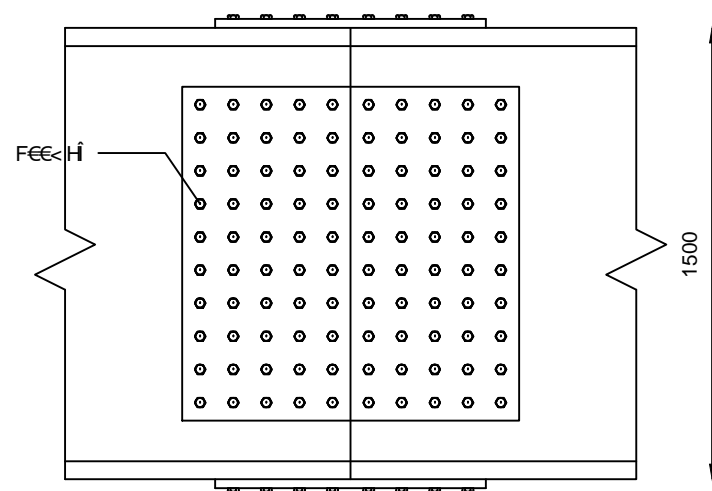

 SAMBUNGAN GELAGAR MELINTANG
 SKALA 1:10



SAMBUNGAN GELAGAR MELINTANG
SKALA 1:25



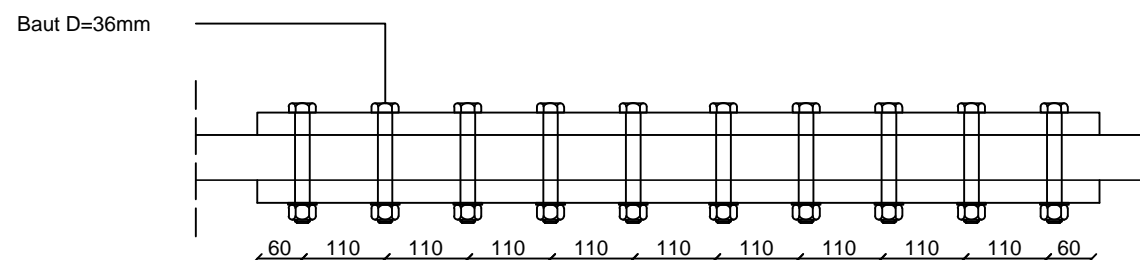
DETAIL SAMBUNGAN BOX
SKALA 1:25



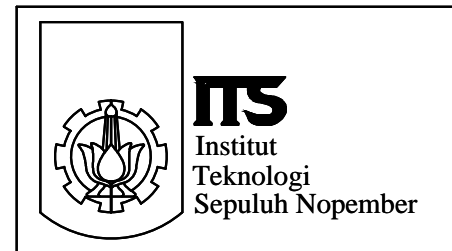
DETAIL SAMBUNGAN BOX (TAMPAK ATAS)
SKALA 1:25

Baut D=36mm

DETAIL A
SKALA 1:10



DETAIL B
SKALA 1:10



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- DETAIL SAMBUNGAN PADA
BOX GIRDER

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

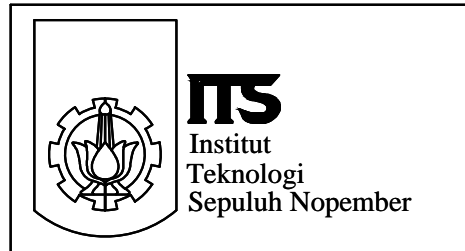
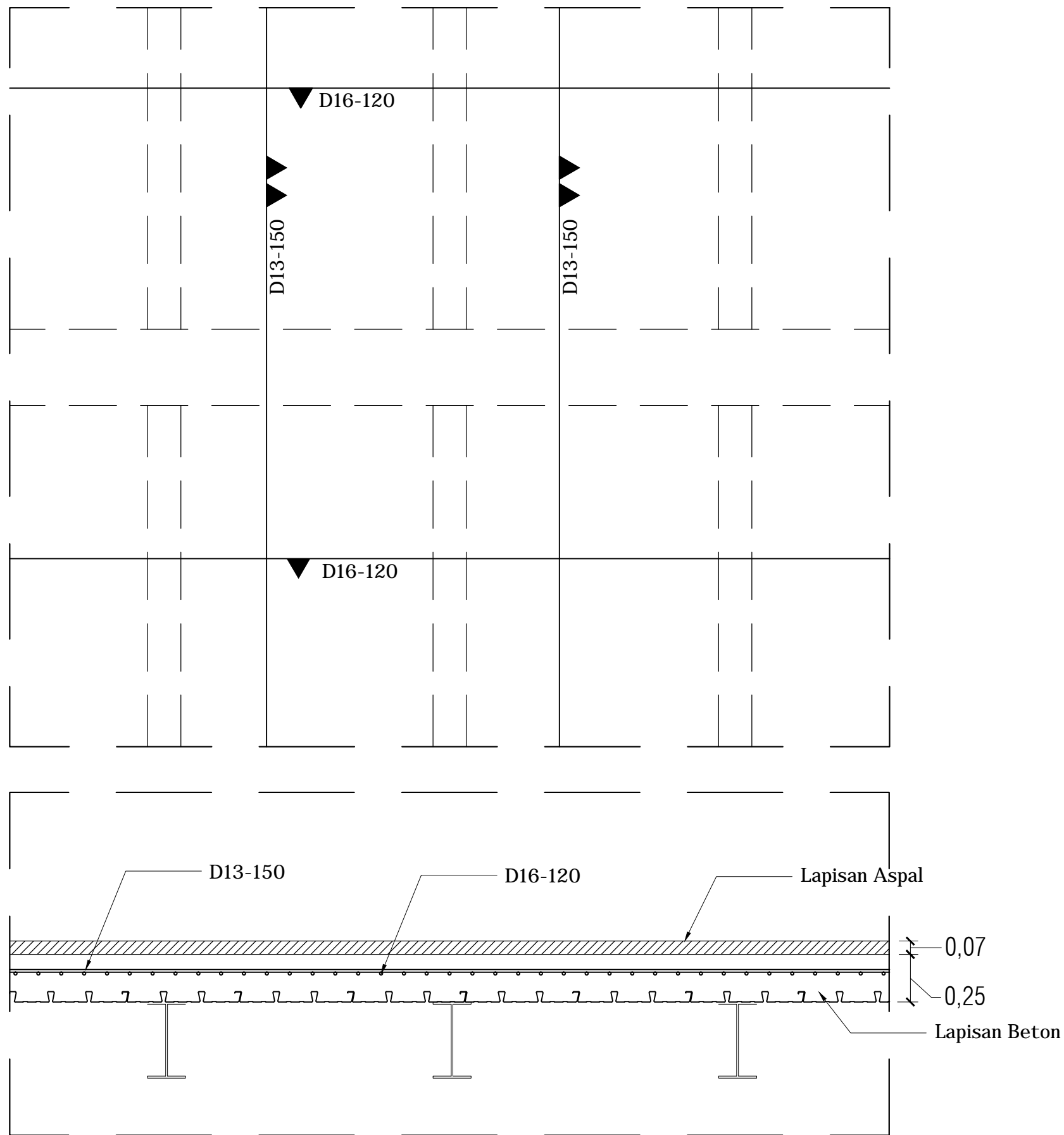
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

13

30



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- PENULANGAN PELAT
KENDARAAN

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

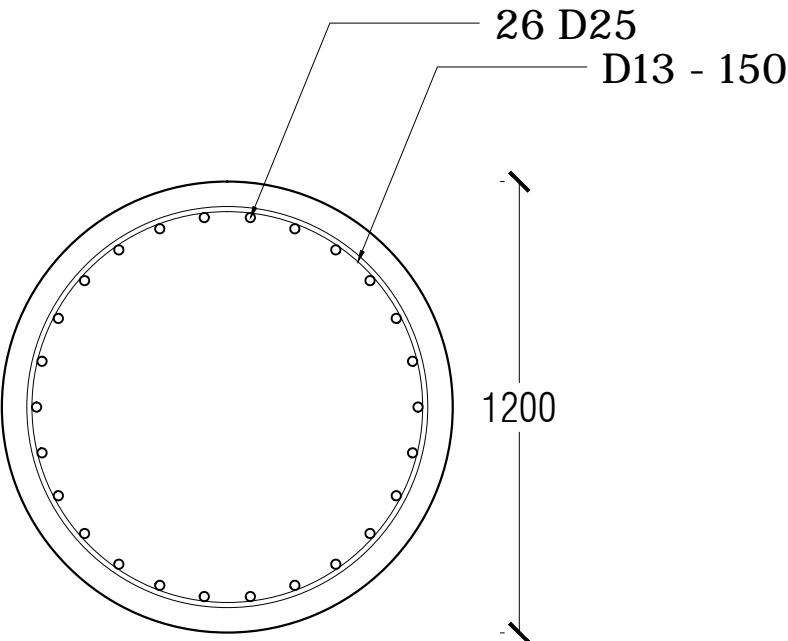
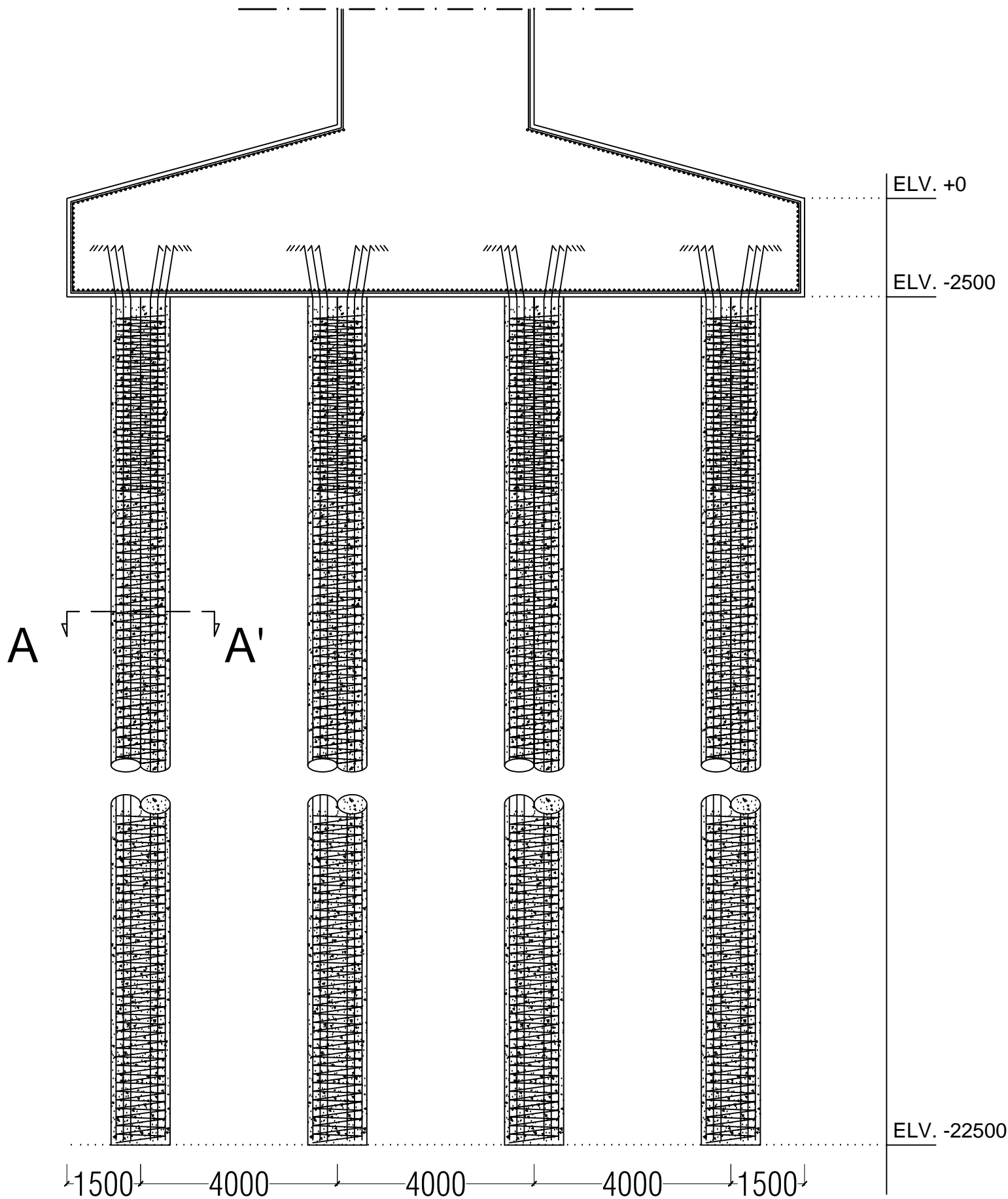
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

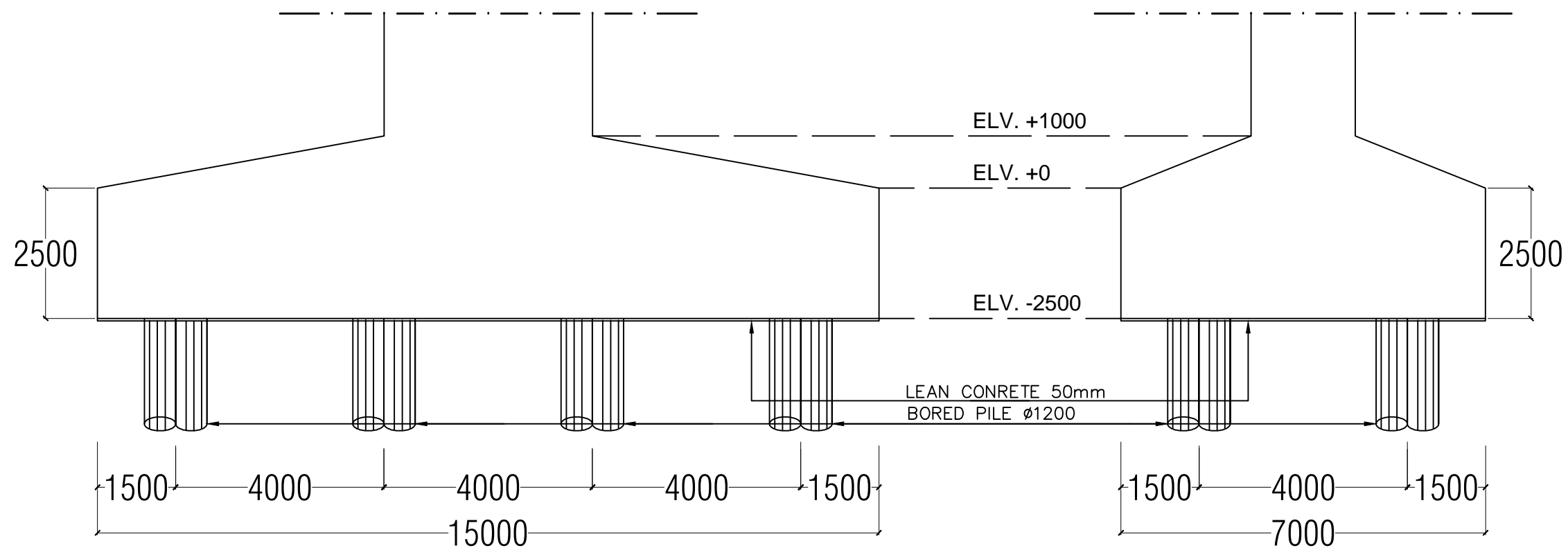
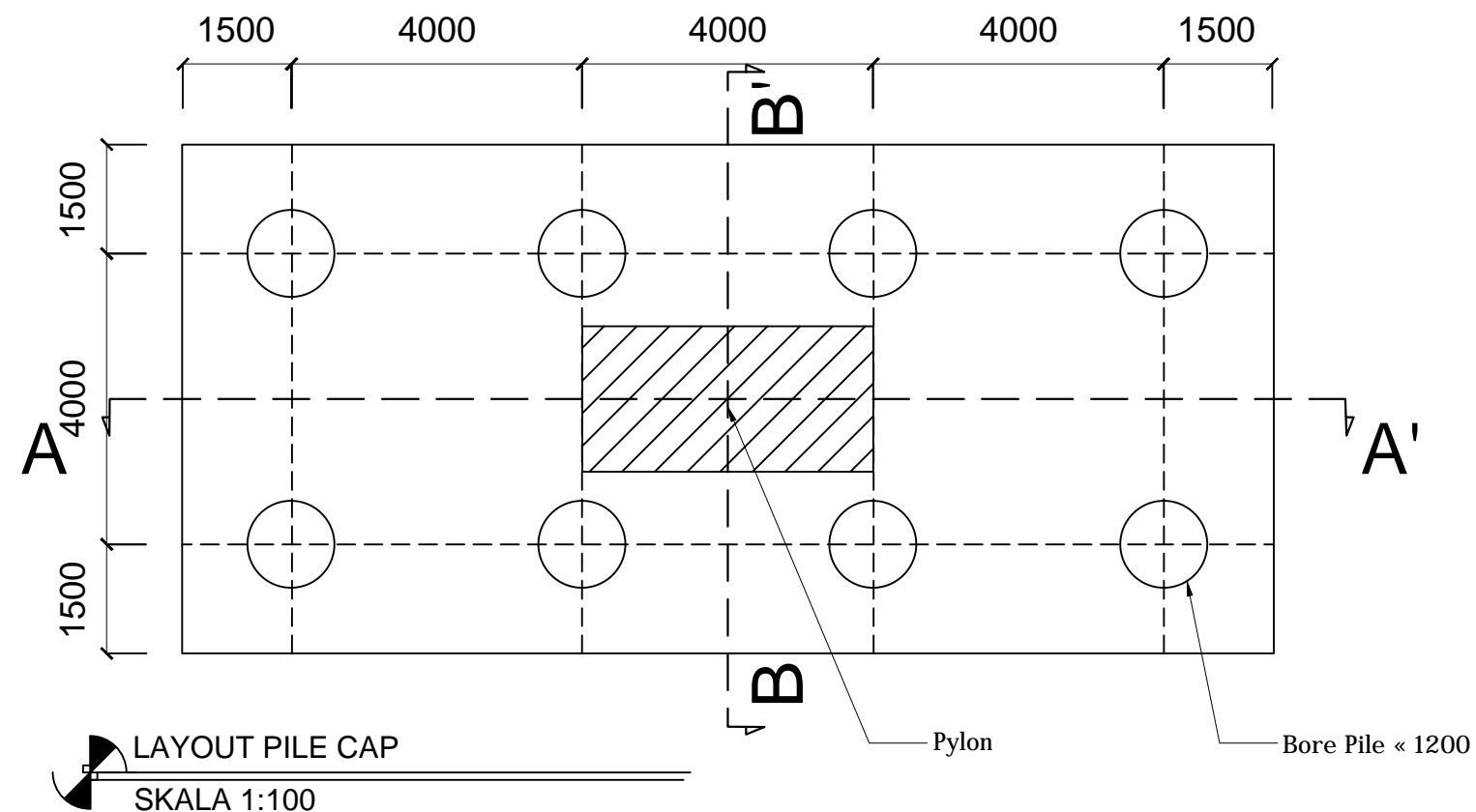
14

30



DETAIL POT. A-A
SKALA 1:20

DETAIL TULANGAN BORE PILE
SKALA 1:100



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- LAYOUT PILE CAP

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

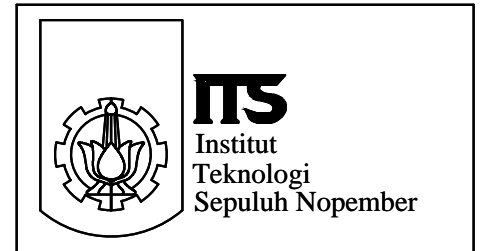
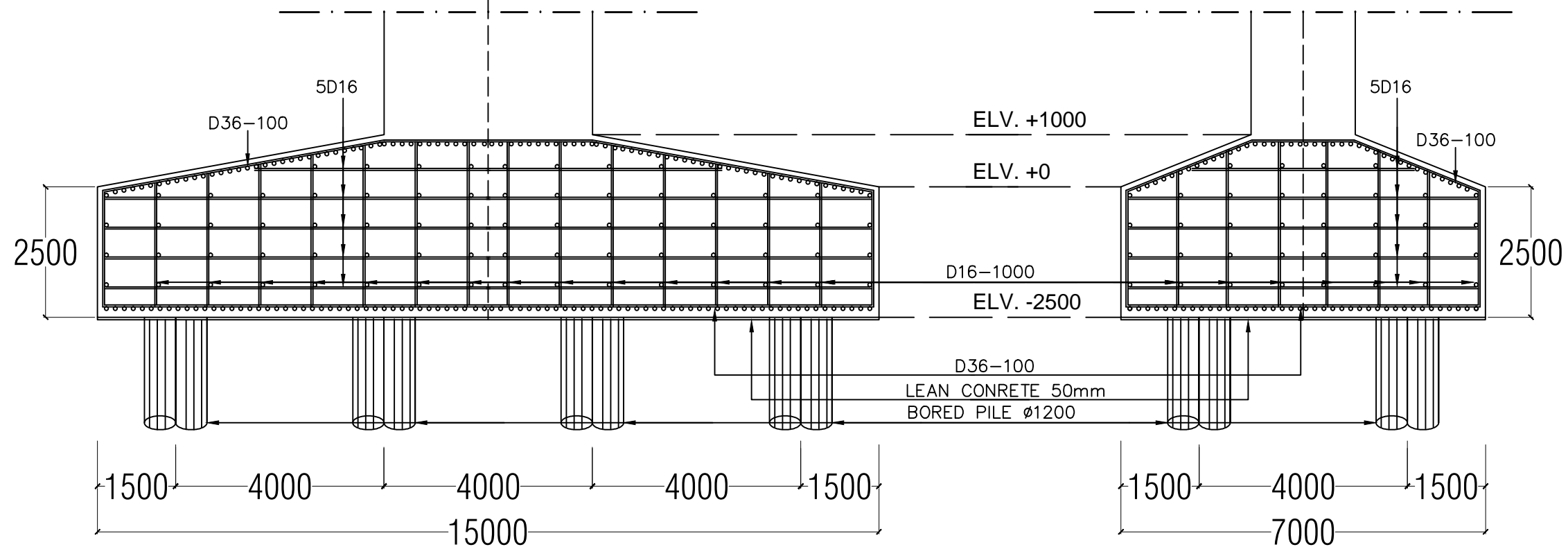
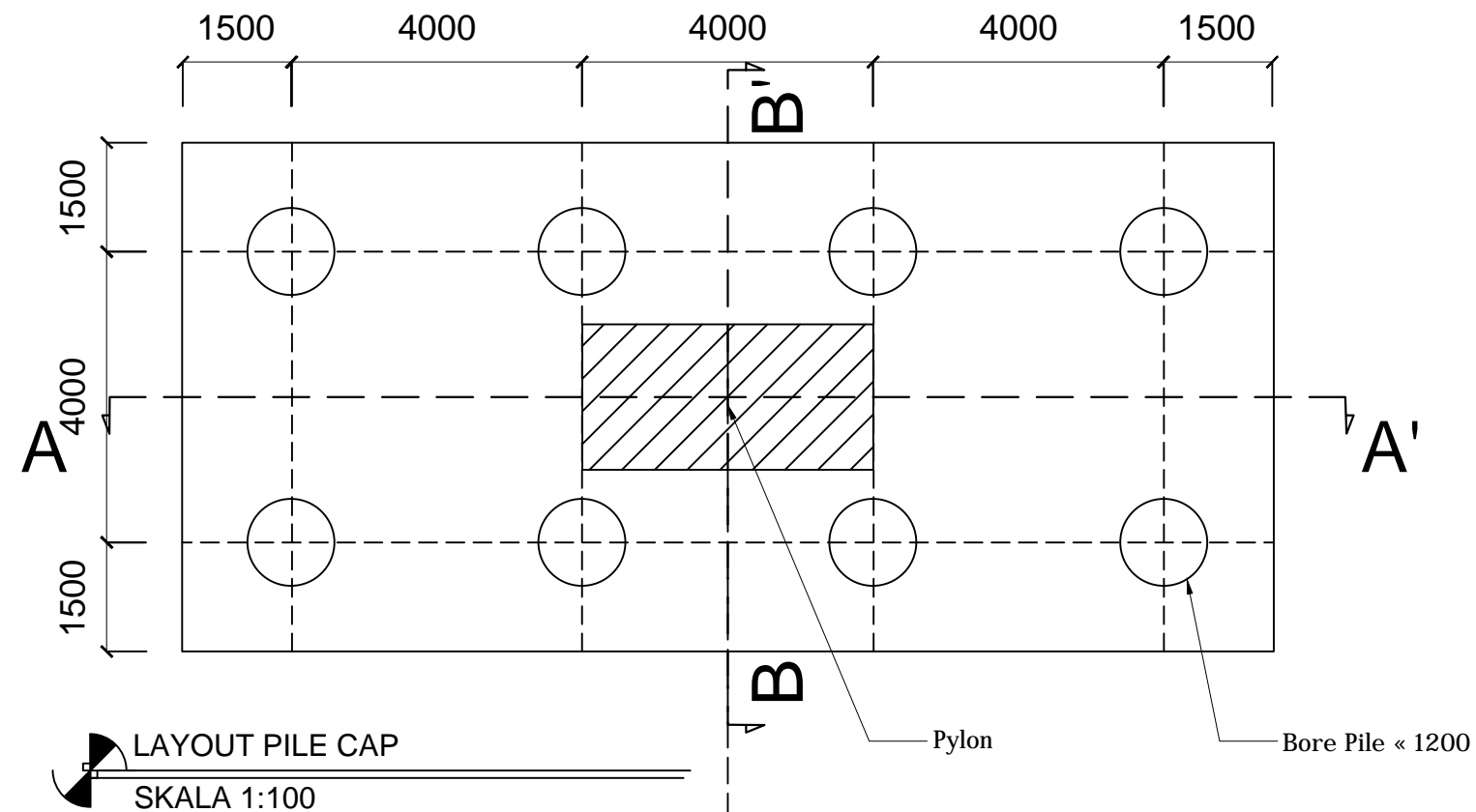
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

16

30



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- PENULANGAN PILE CAP

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

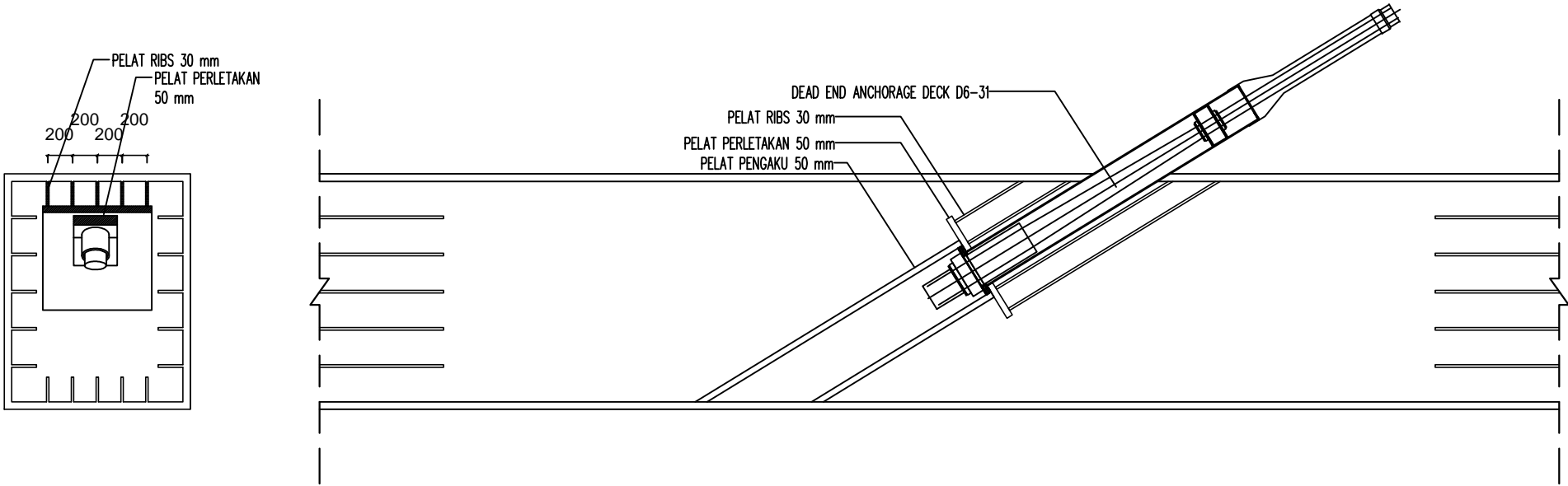
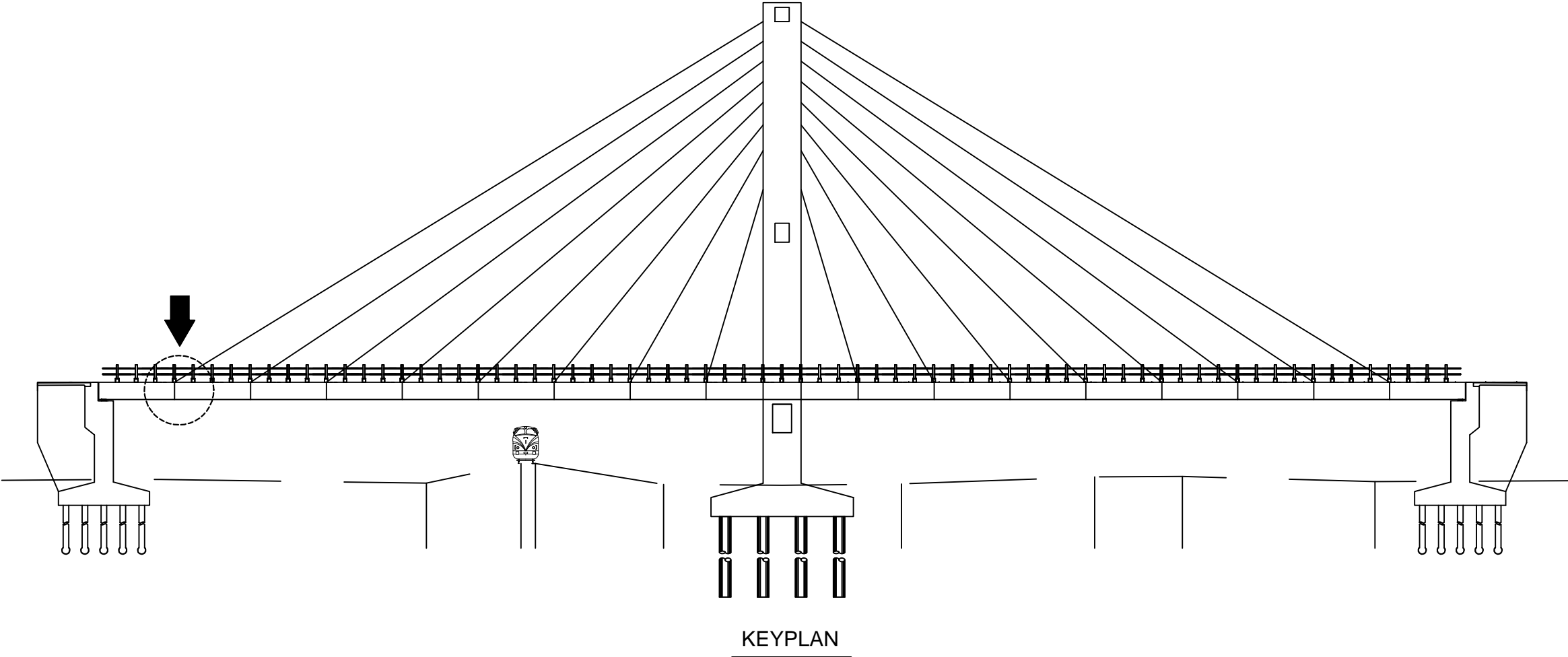
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

17

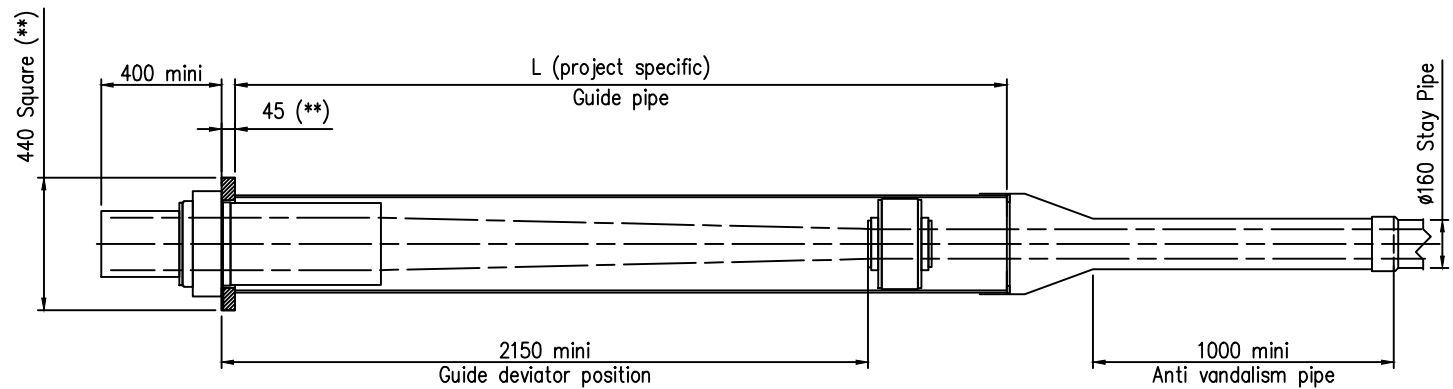
30



DETAIL ANGKUR PADA BOX GIRDER
SKALA 1:50

VSL

GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
STRESSING END ANCHORAGE DECK DRT 6-31
Ver 1 - 27.03.2002

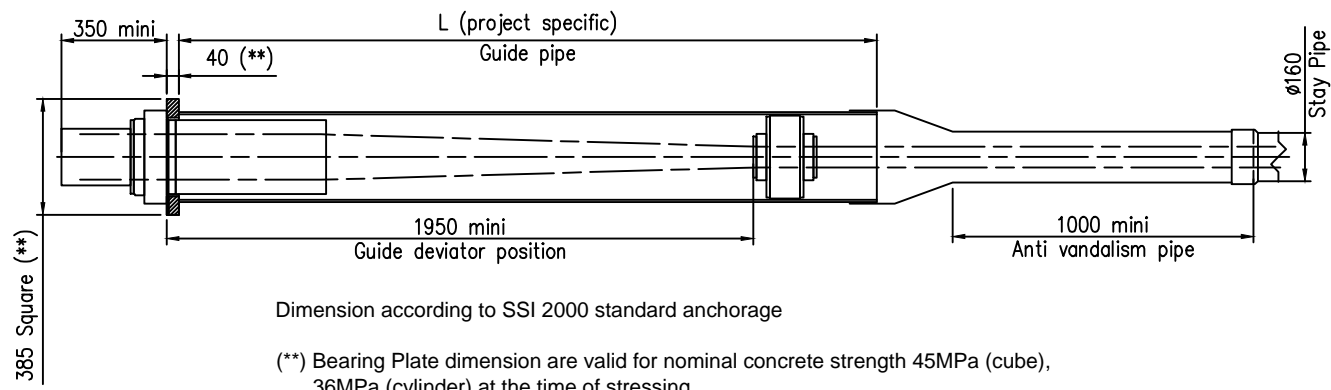


Dimension according to SSI 2000 standard anchorage

(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing

VSL

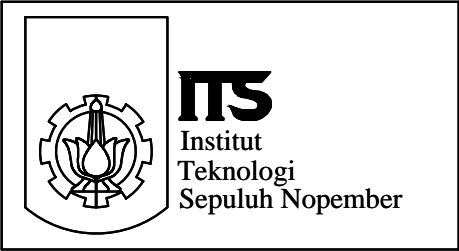
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
STRESSING END ANCHORAGE DECK DRT 6-22
Ver 1 - 27.03.2002



Dimension according to SSI 2000 standard anchorage

(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing

ANGKER HIDUP PADA DEK
SKALA 1:25



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- ANGKUR HIDUP PADA DEK

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 000028

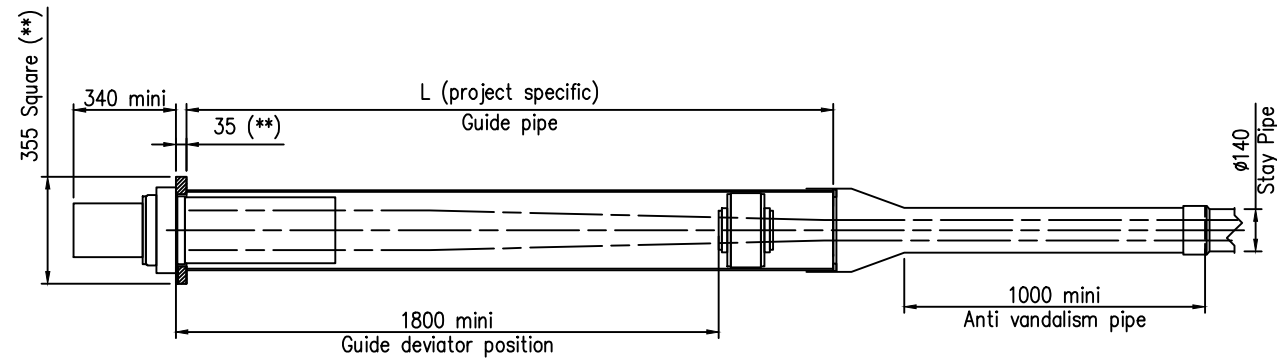
NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

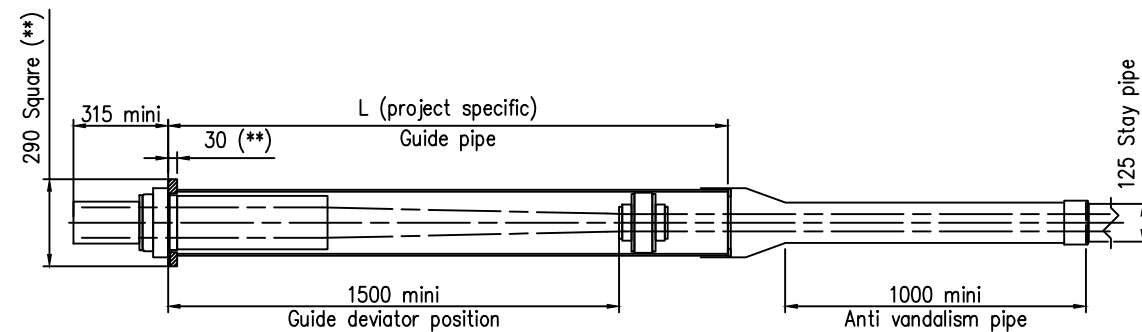
NOMOR GAMBAR	JUMLAH
19	30

VSI
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
STRESSING END ANCHORAGE DECK DRT 6-19
Ver 1 - 27.03.2002



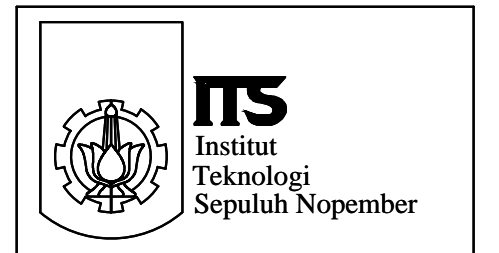
Dimension according to SSI 2000 standard anchorage
(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube),
36MPa (cylinder) at the time of stressing

VSI
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
STRESSING END ANCHORAGE DECK DRT 6-12
Ver 1 - 27.03.2002



Dimension according to SSI 2000 standard anchorage
(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube),
36MPa (cylinder) at the time of stressing

 **ANGKER HIDUP PADA DEK**
SKALA 1:25



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- ANGKUR HIDUP PADA DEK

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

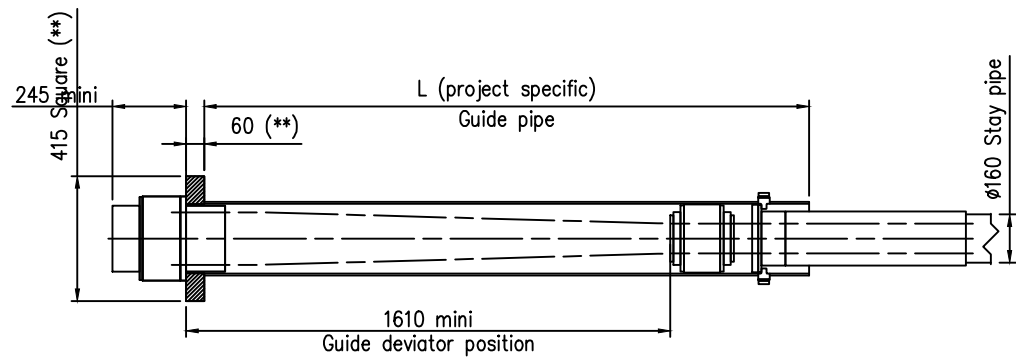
NOMOR GAMBAR

JUMLAH

20

30

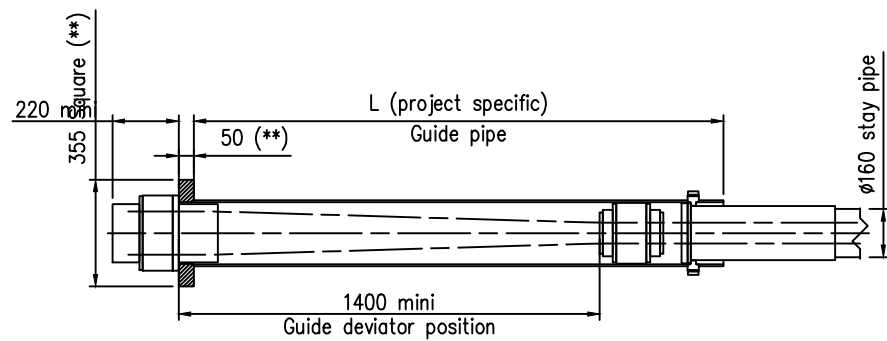
VSL
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
DEAD END ANCHORAGE PYLON DS 6-31
Ver 1 - 25.03.2002



Dimension according to SSI 2000 standard anchorage

(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing

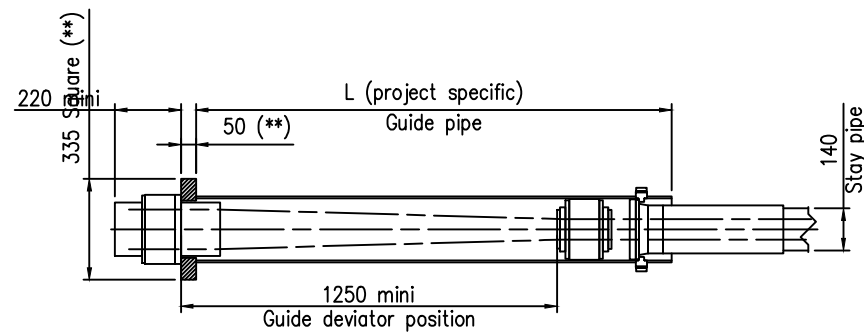
VSL
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
DEAD END ANCHORAGE PYLON DS 6-22
Ver 1 - 25.03.2002



Dimension according to SSI 2000 standard anchorage

(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing

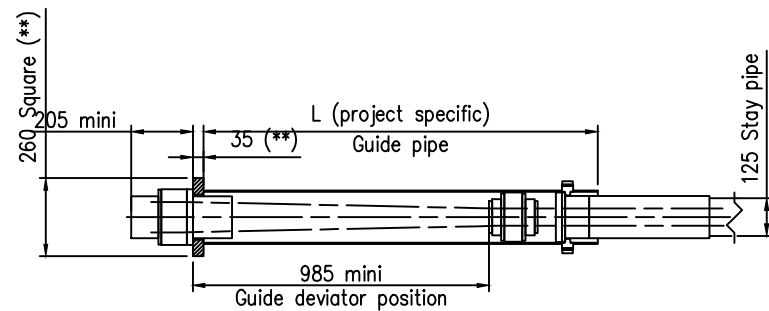
VSL
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
DEAD END ANCHORAGE PYLON DS 6-19
Ver 1 - 25.03.2002



Dimension according to SSI 2000 standard anchorage

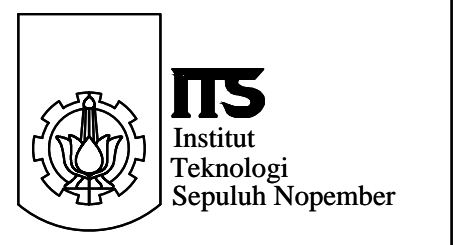
(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing

VSL
GENERAL ASSEMBLY
STAY CABLE SYSTEM SSI 2000
DEAD END ANCHORAGE PYLON DS 6-12
Ver 1 - 25.03.2002



Dimension according to SSI 2000 standard anchorage

(**) Bearing Plate dimension are valid for nominal concrete strength 45MPa (cube), 36MPa (cylinder) at the time of stressing



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- ANGKUR MATI PADA PYLON

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

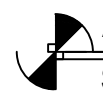
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

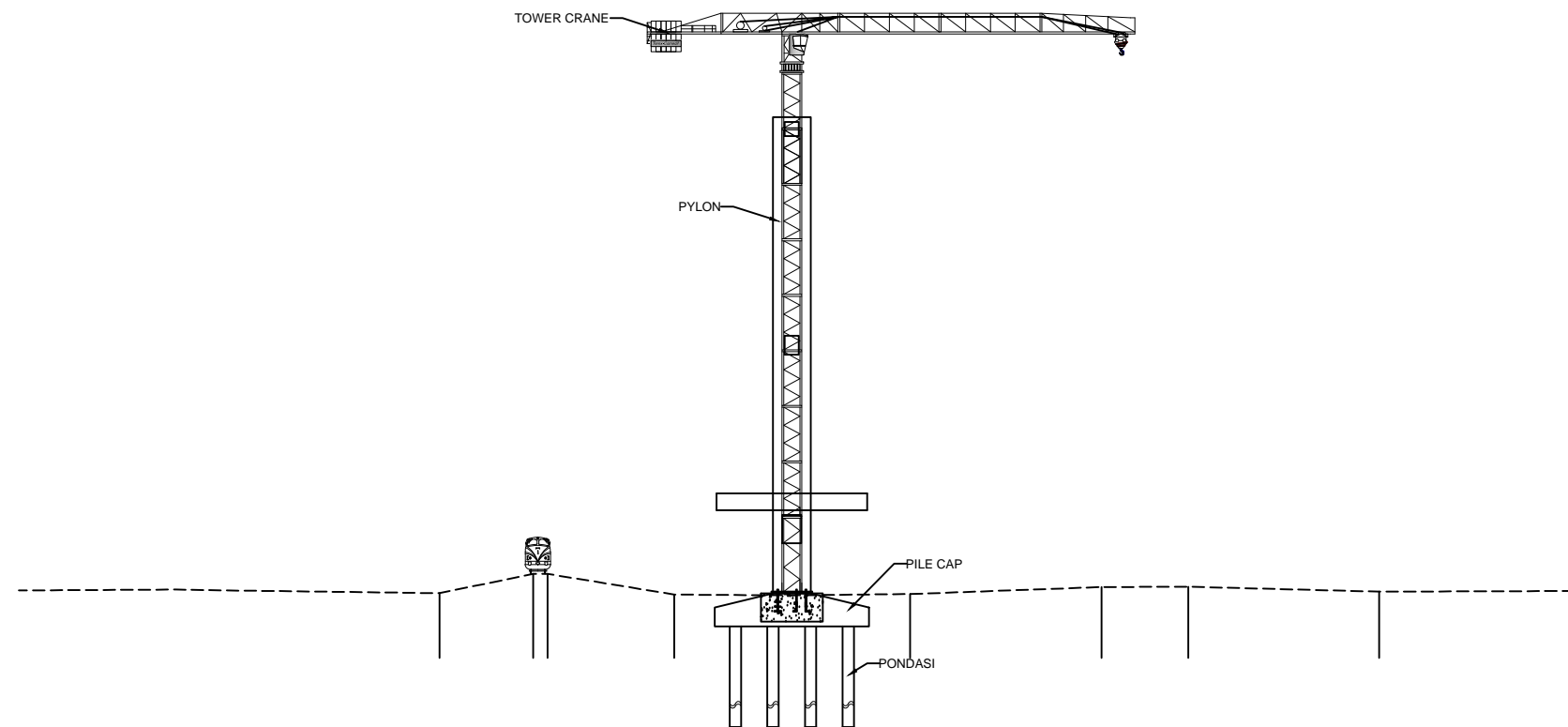
21

30

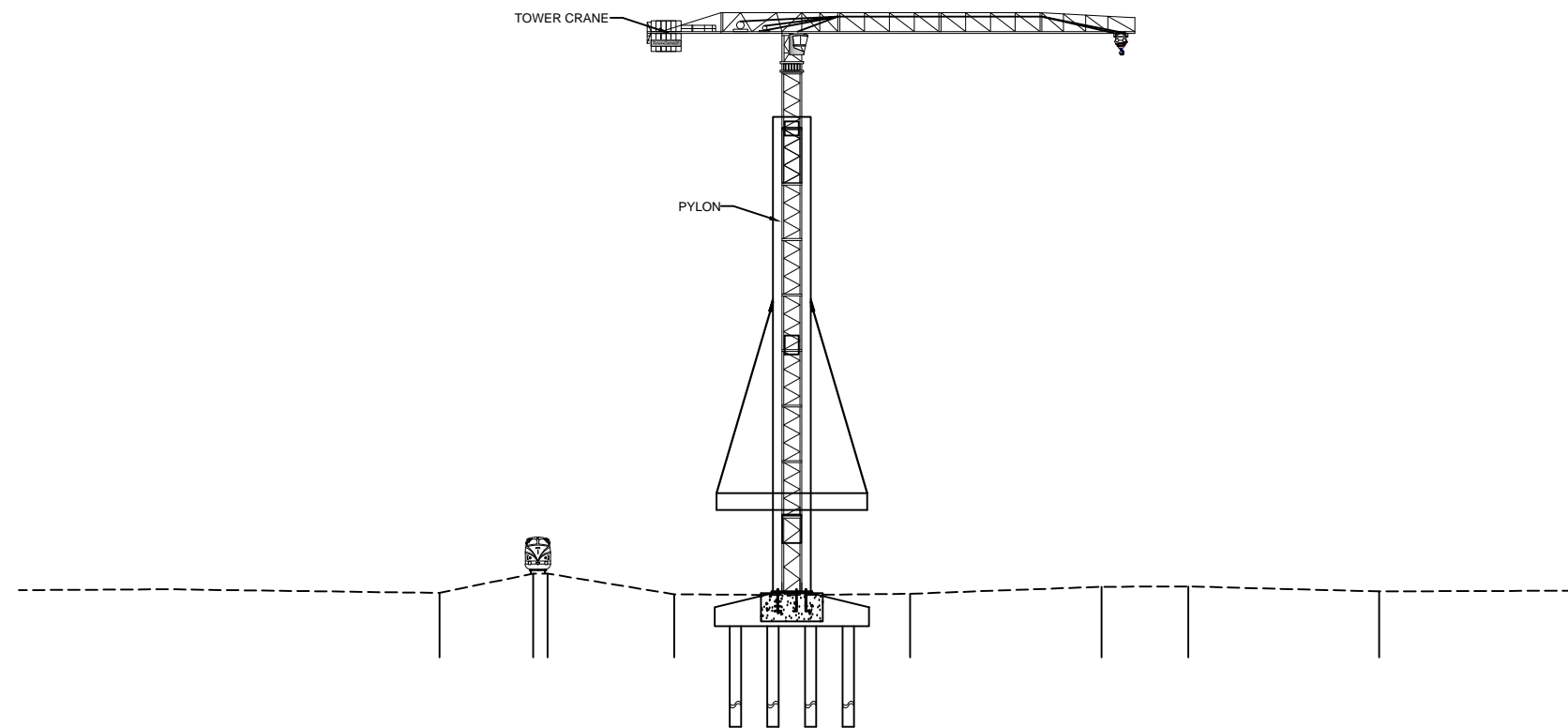



ANGKER MATI PADA PYLON

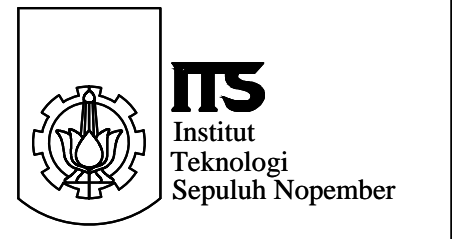
SKALA 1:25



 **TAHAP 1: PEMASANGAN MG9**
SKALA 1:750



 **TAHAP 2: TENSIONING C8**
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 1: PEMASANGAN MG9
- TAHAP 2: TENSIONING C8

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

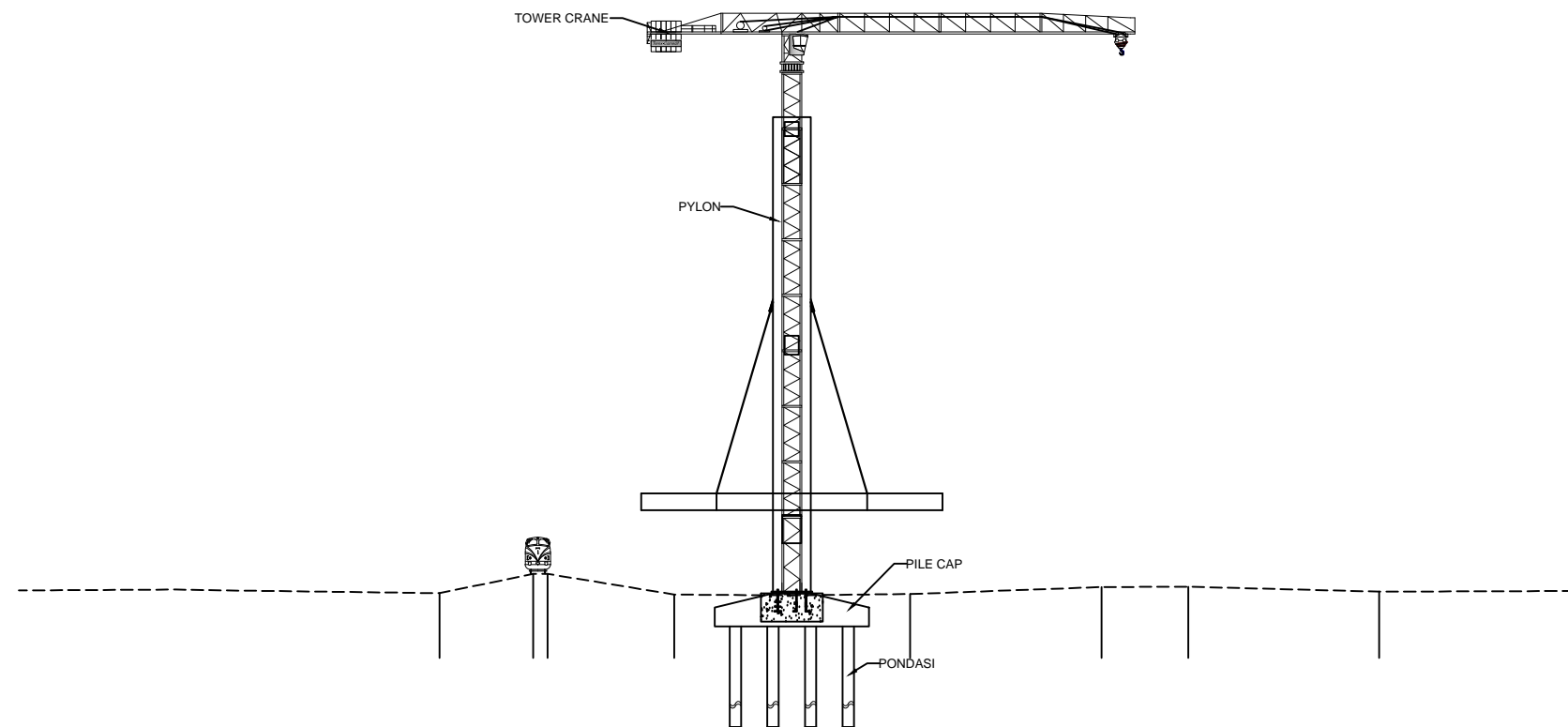
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

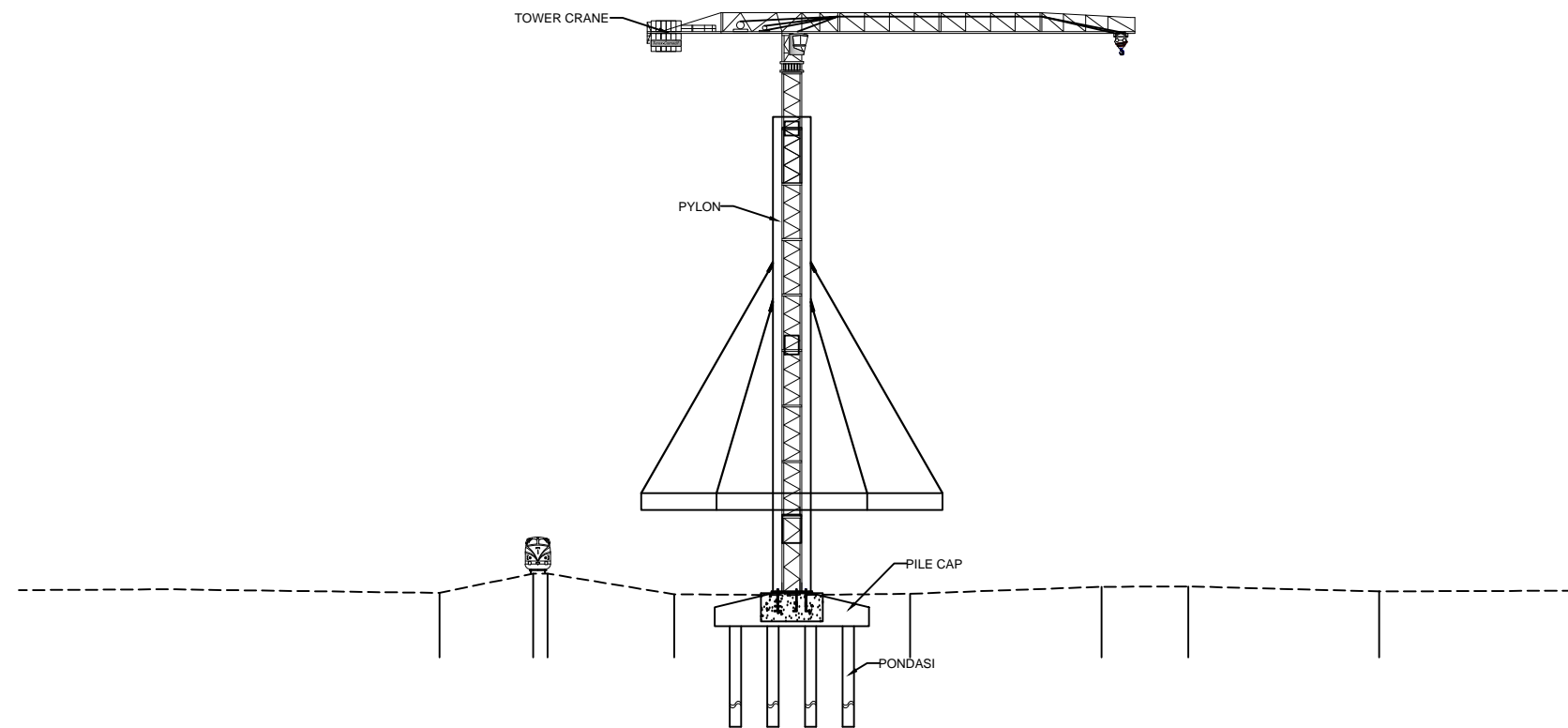
JUMLAH


22

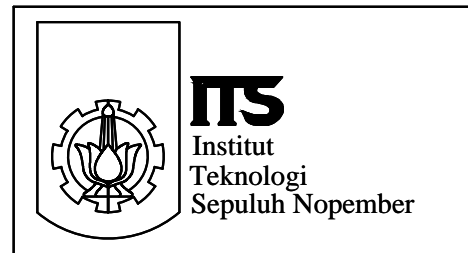
30



 **TAHAP 3: PEMASANGAN MG8**
SKALA 1:750



 **TAHAP 4: TENSIONING C7**
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 3: PEMASANGAN MG8
- TAHAP 4: TENSIONING C7

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

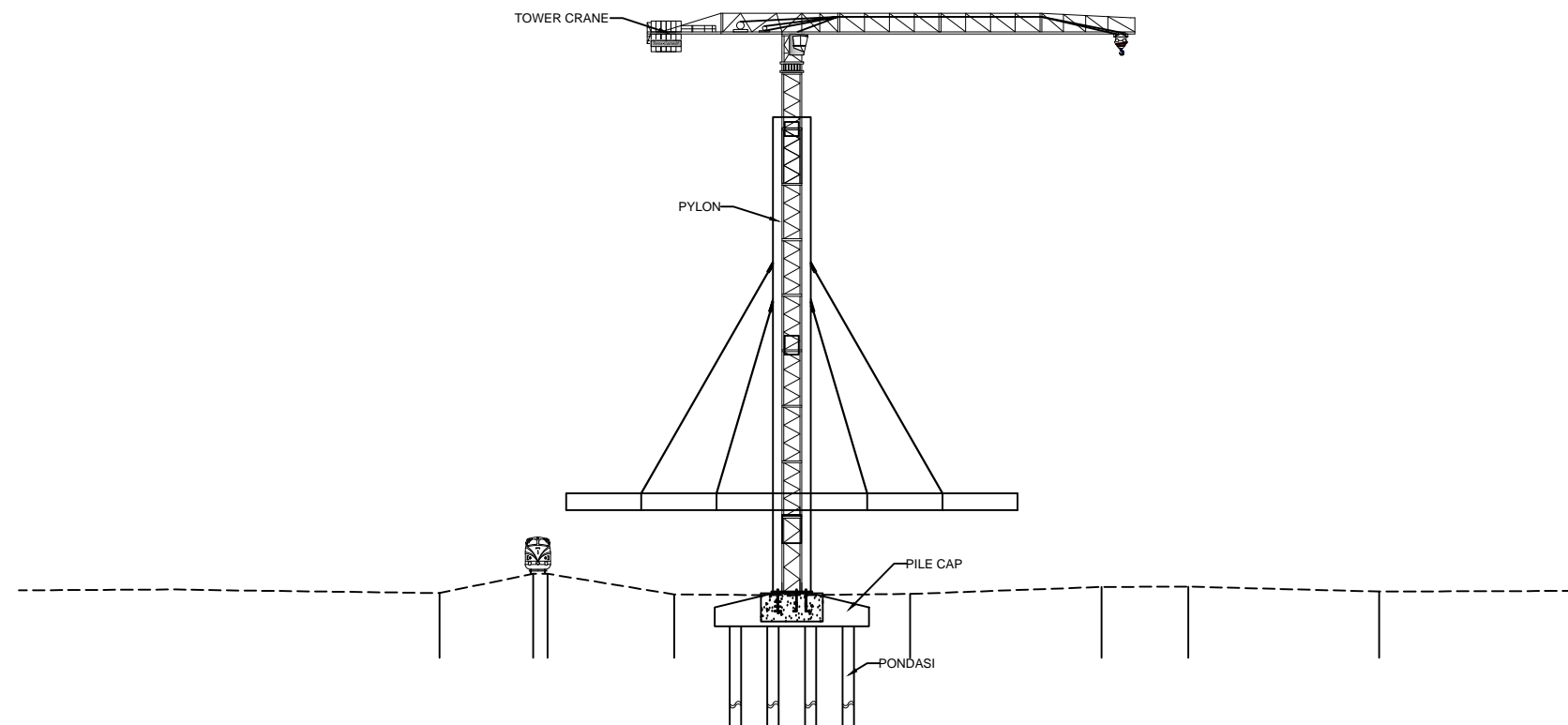
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001


NOMOR GAMBAR

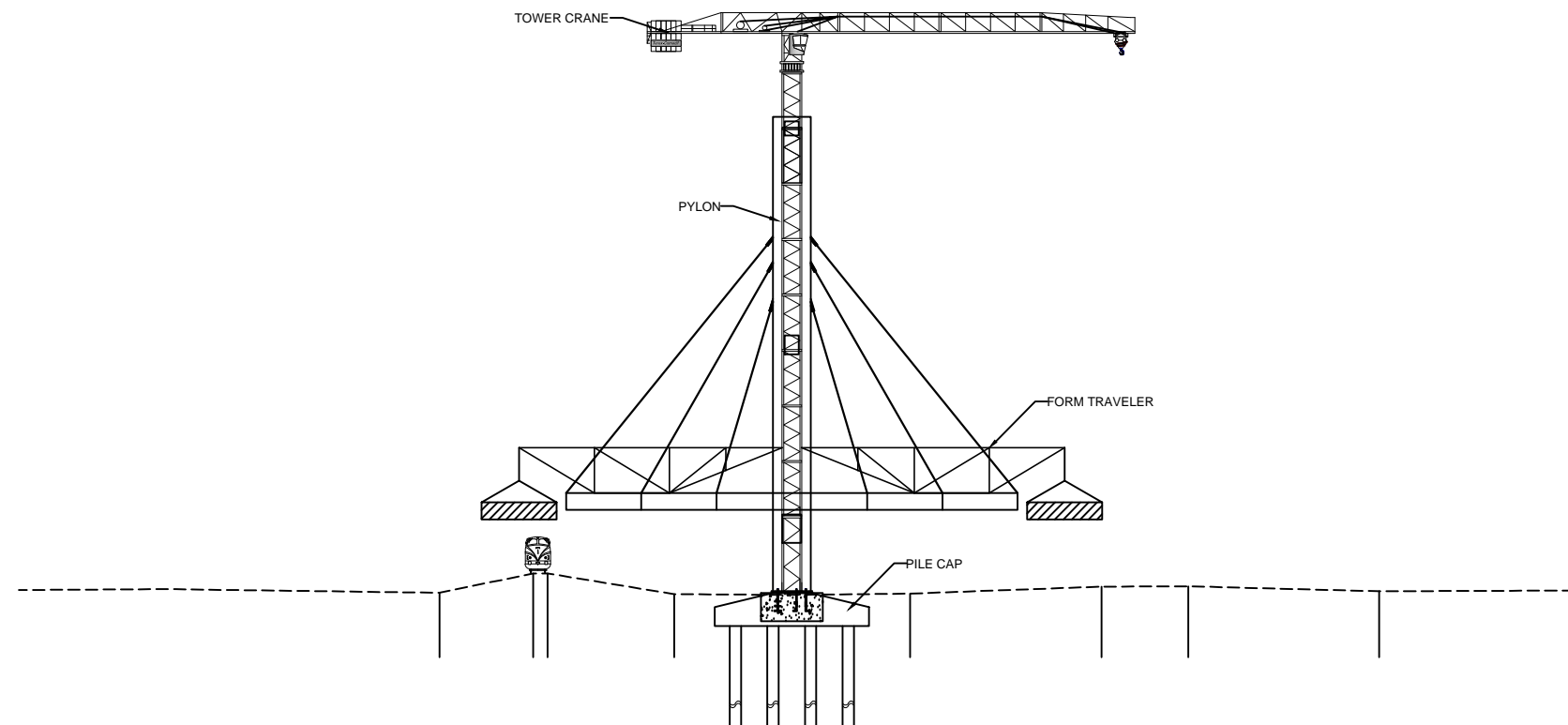
JUMLAH

23

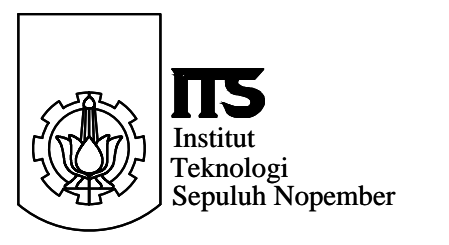
30



 **TAHAP 5: PEMASANGAN MG7**
SKALA 1:750



 **TAHAP 6: TENSIONING C6**
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 5: PEMASANGAN MG7
- TAHAP 6: TENSIONING C6

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

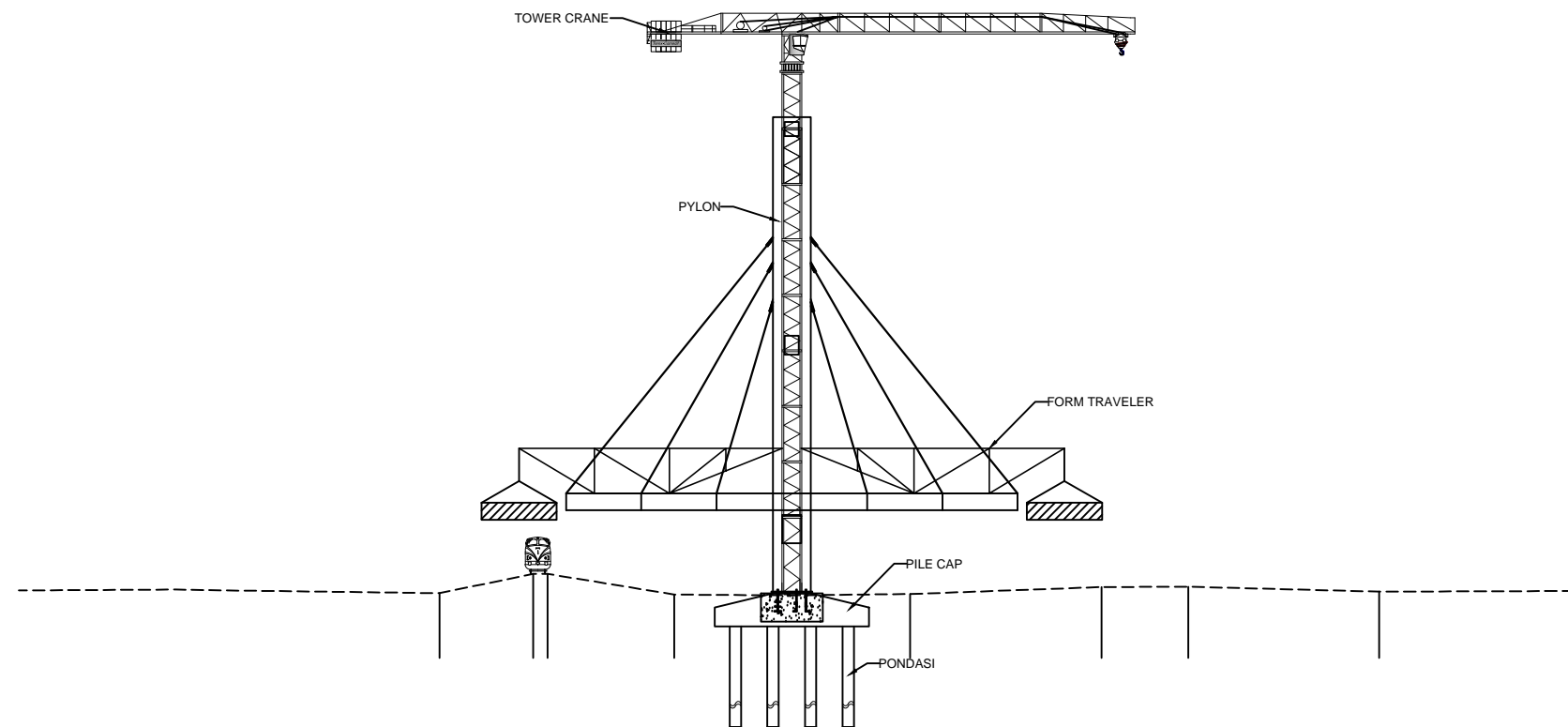
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

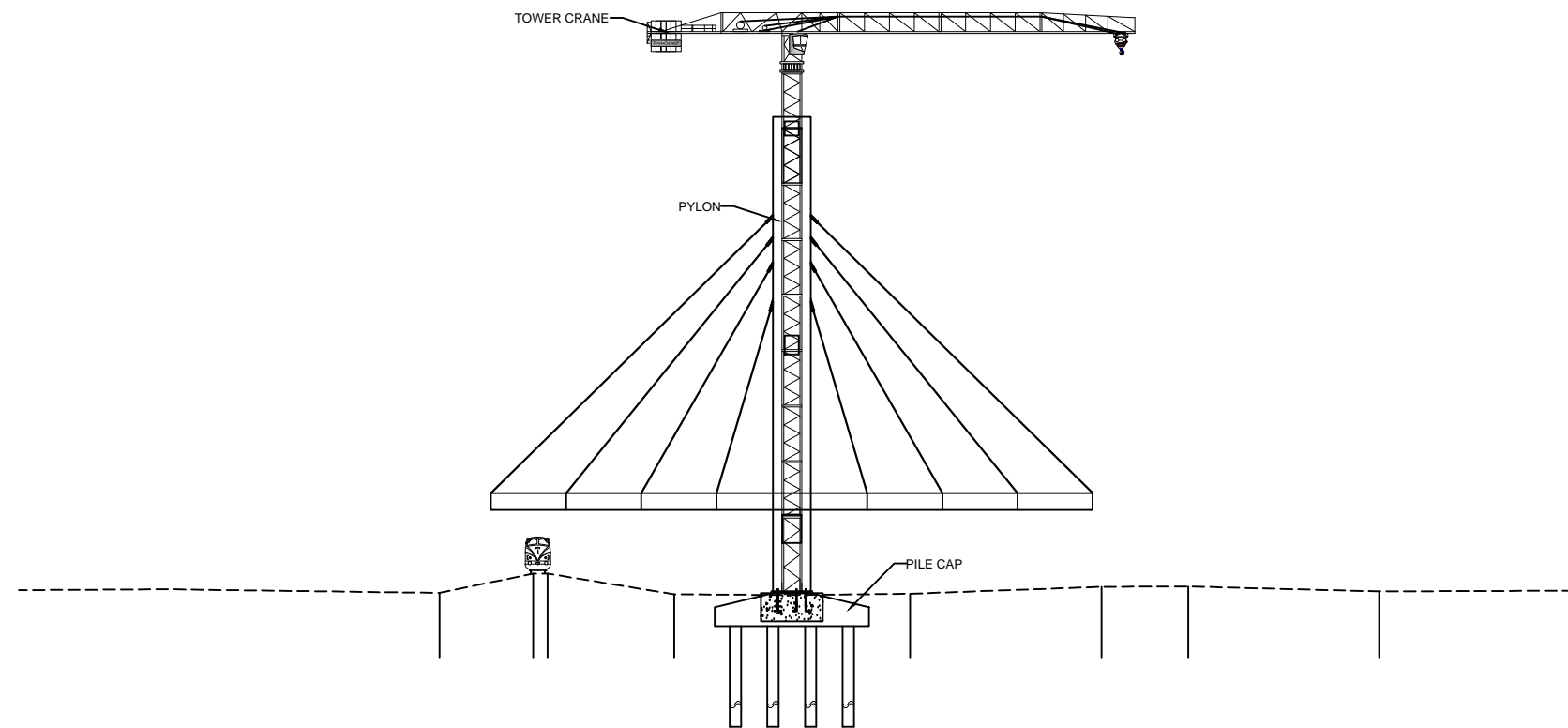
JUMLAH

24

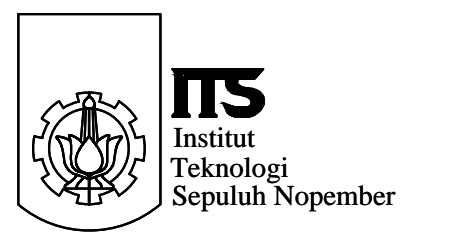
30



TAHAP 7: PEMASANGAN MG6
SKALA 1:750



TAHAP 8: TENSIONING C5
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 7: PEMASANGAN MG6
- TAHAP 8: TENSIONING C5

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

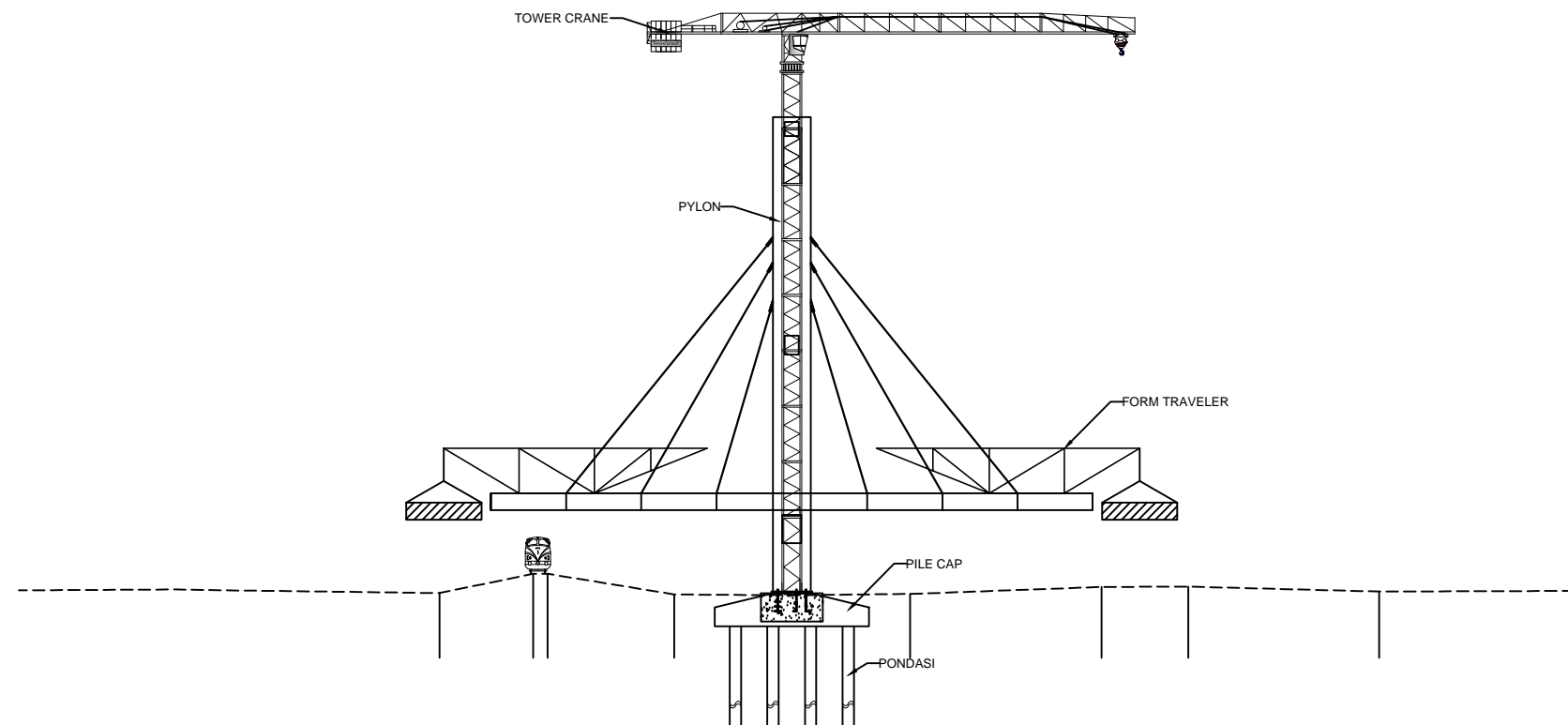
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

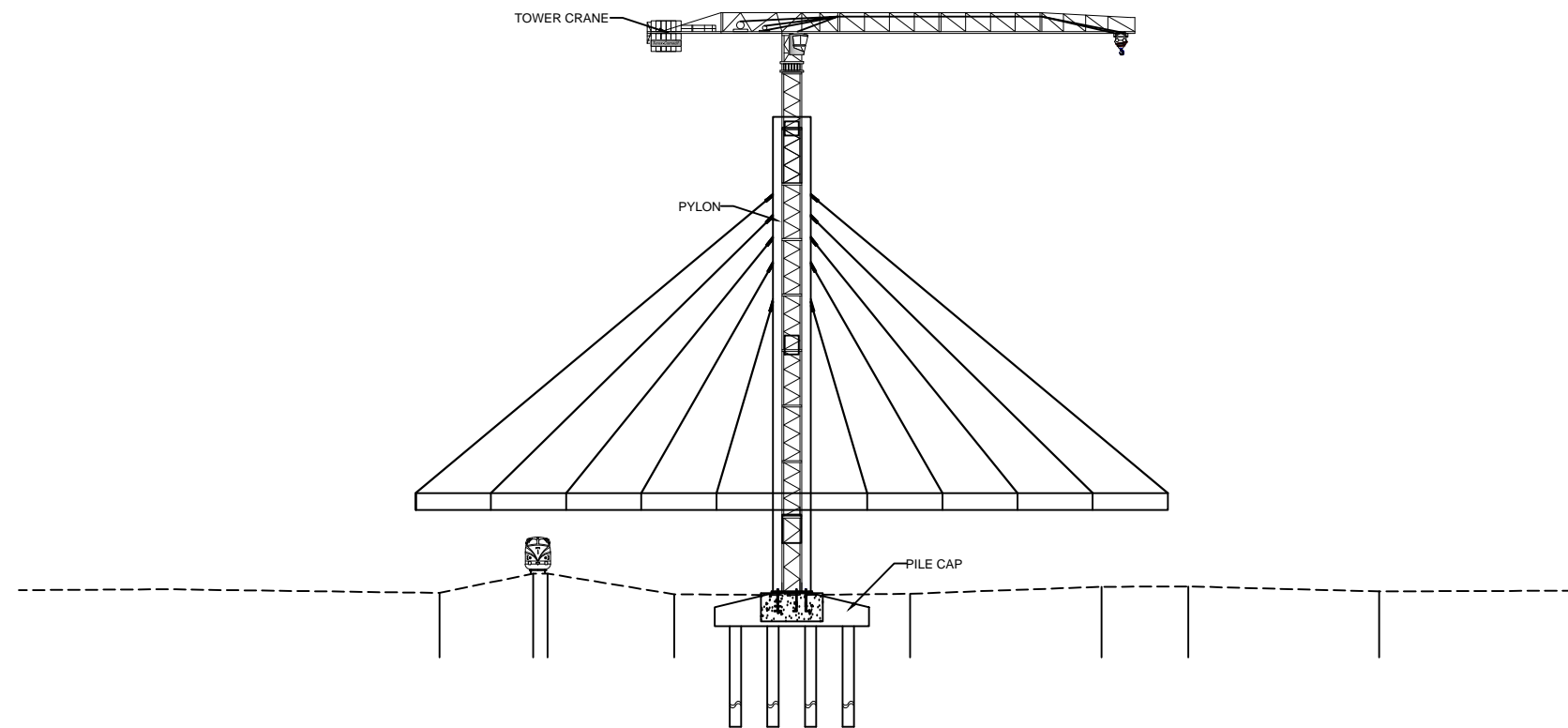
JUMLAH

25

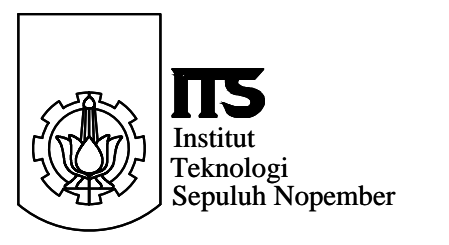
30



TAHAP 9: PEMASANGAN MG5
SKALA 1:750



TAHAP 10: TENSIONING C4
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 9: PEMASANGAN MG5
- TAHAP 10: TENSIONING C4

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

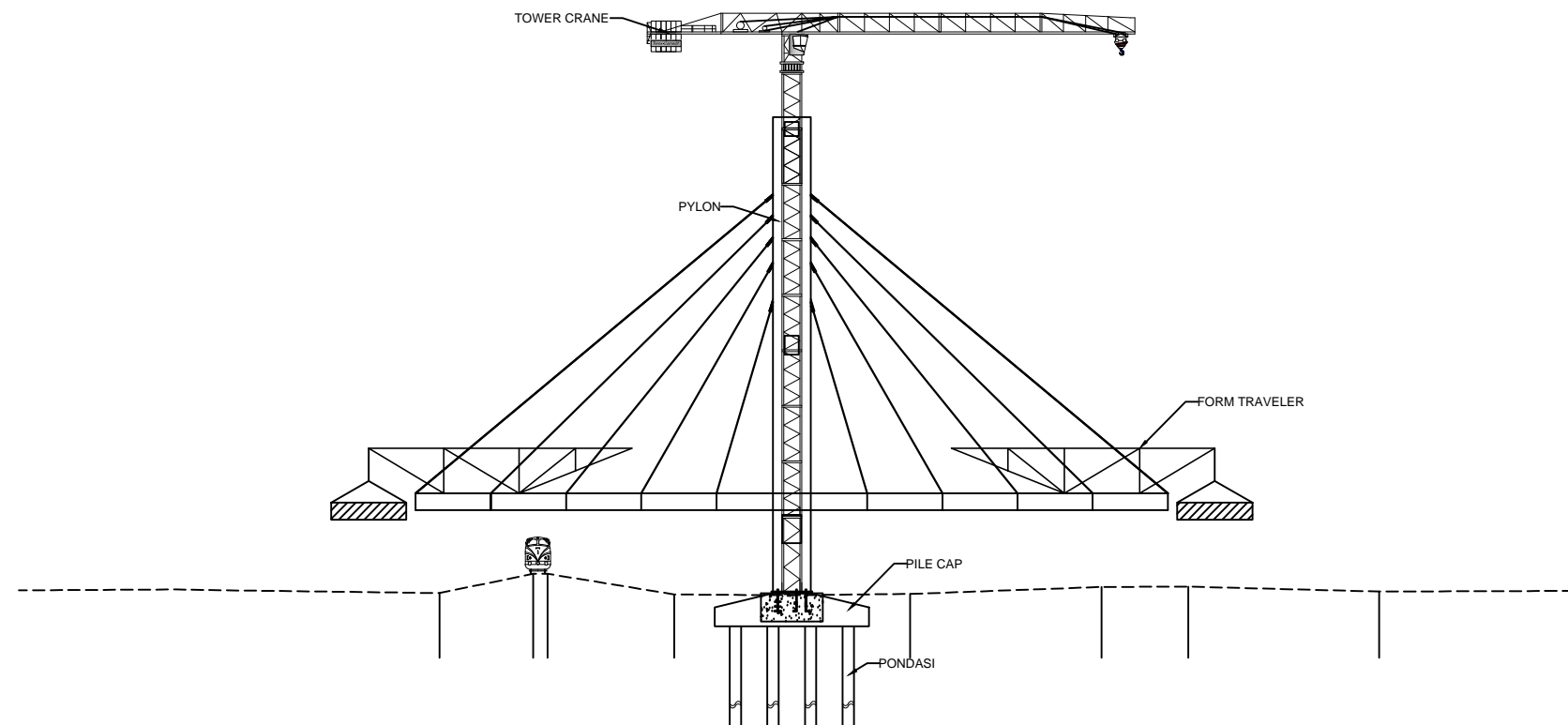
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

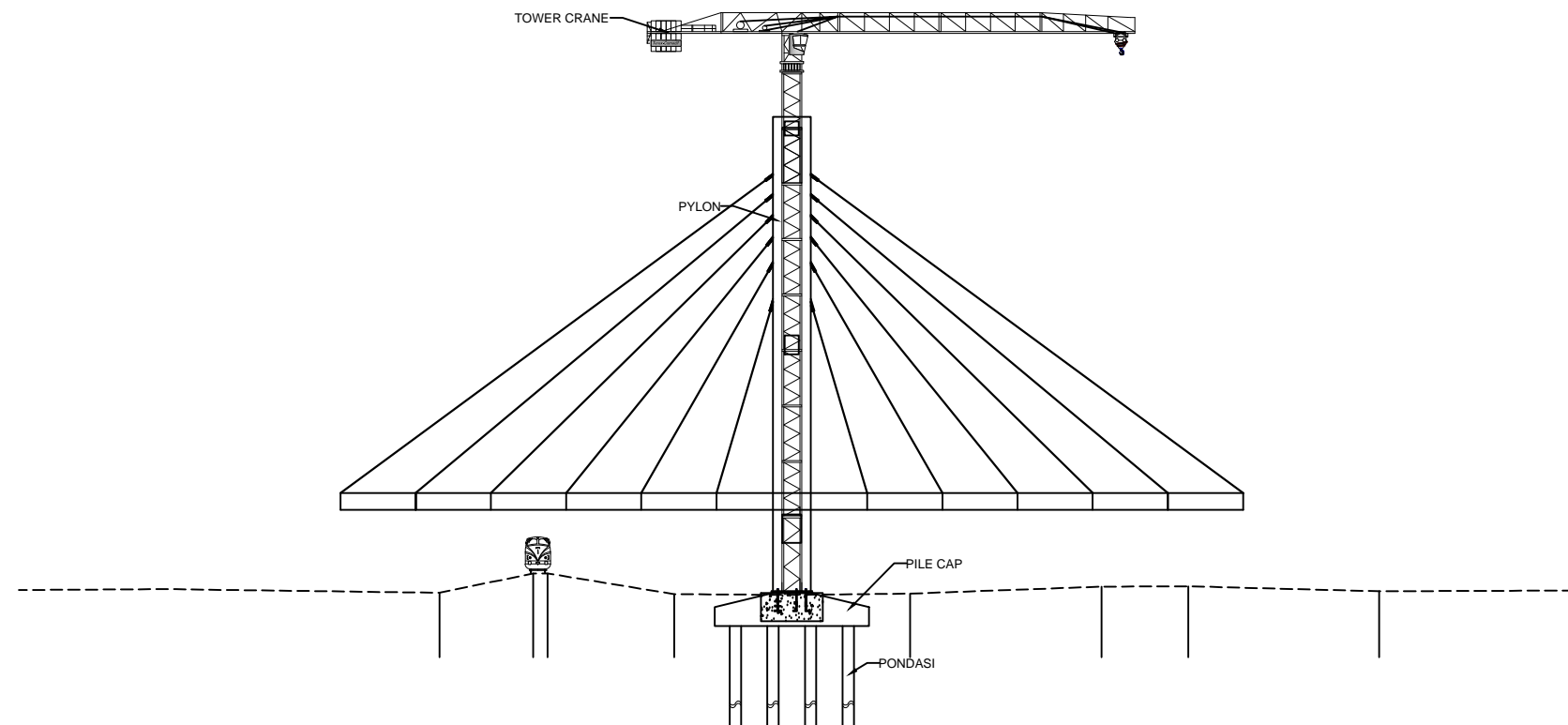
JUMLAH

26

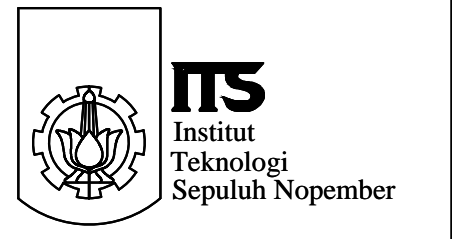
30



TAHAP 11: PEMASANGAN MG4
SKALA 1:750



TAHAP 12: TENSIONING C3
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 11: PEMASANGAN MG4
- TAHAP 12: TENSIONING C3

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

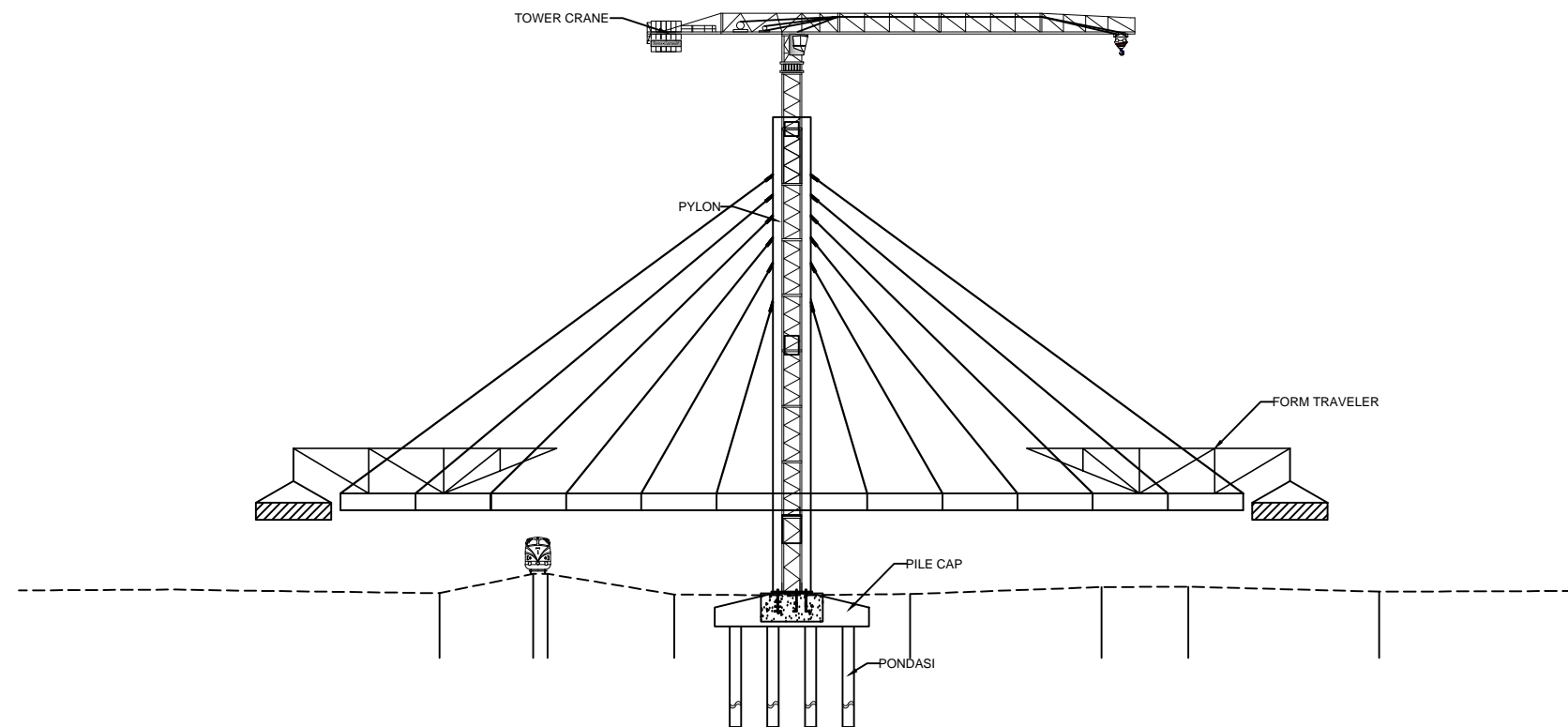
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

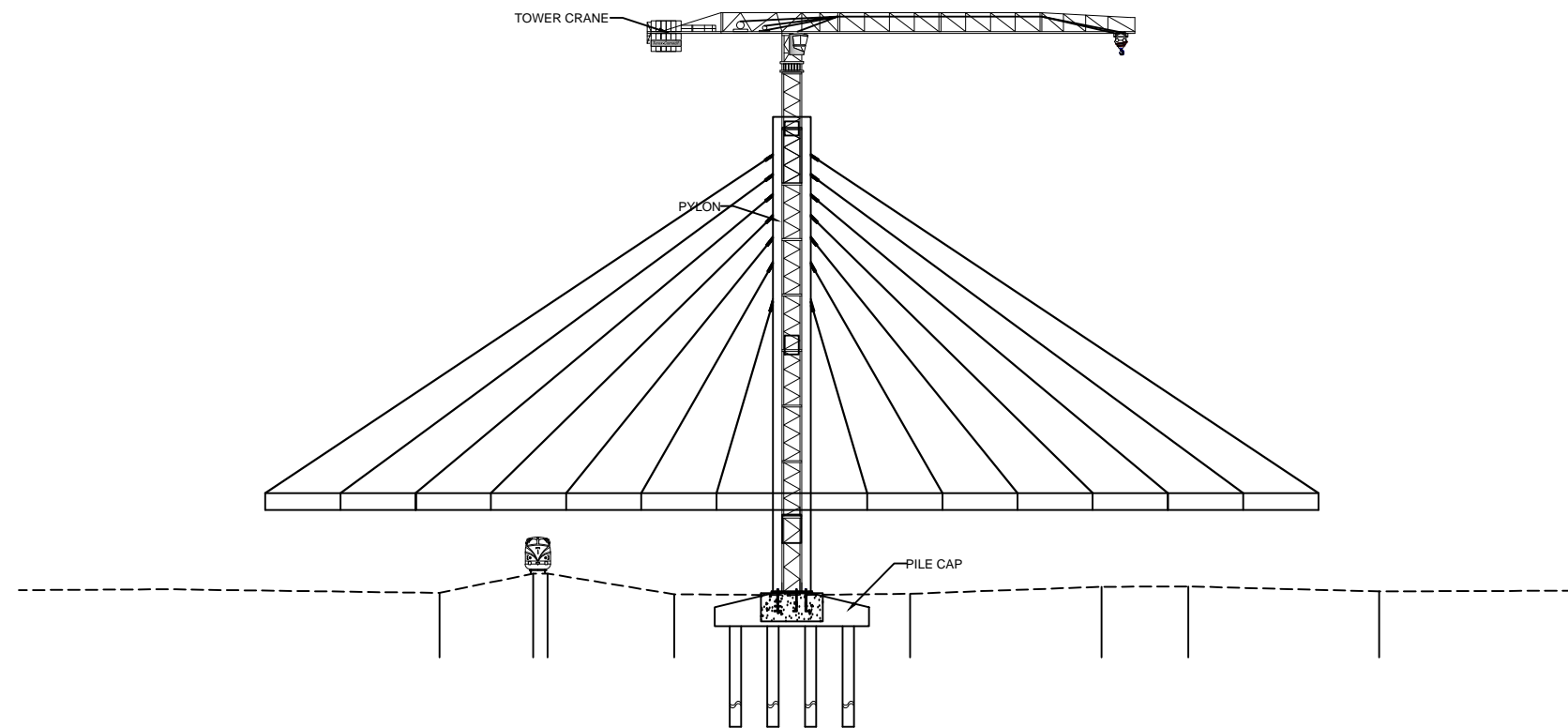
JUMLAH

27

30



TAHAP 13: PEMASANGAN MG3
SKALA 1:750



TAHAP 14: TENSIONING C2
SKALA 1:750

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 13: PEMASANGAN MG3
- TAHAP 14: TENSIONING C2

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

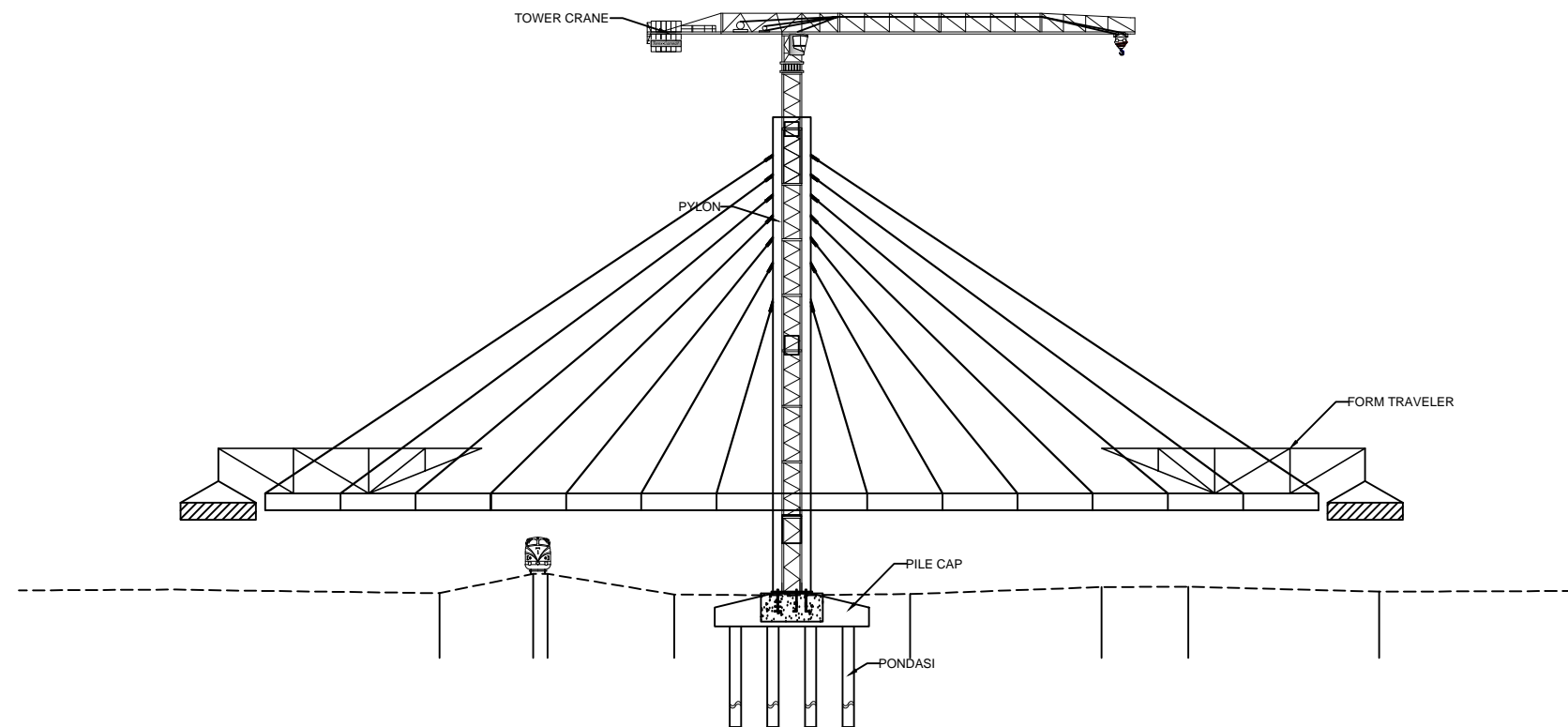
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

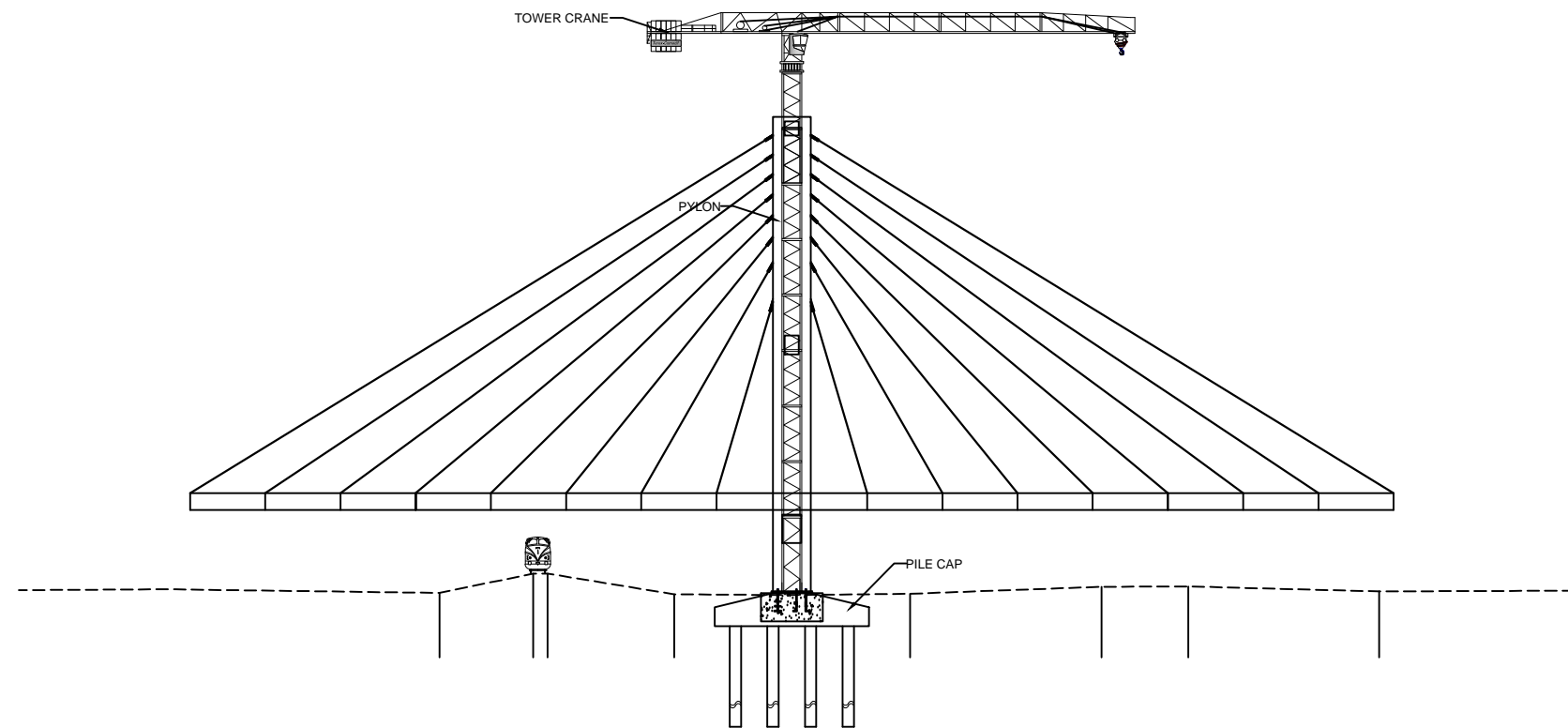
JUMLAH

28

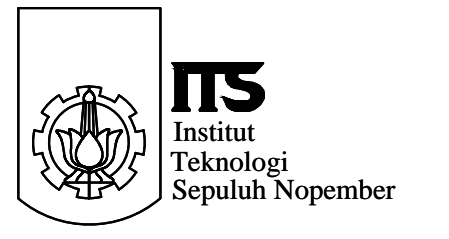
30



TAHAP 15: PEMASANGAN MG2
SKALA 1:750



TAHAP 16: TENSIONING C1
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 15: PEMASANGAN MG2
- TAHAP 16: TENSIONING C1

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

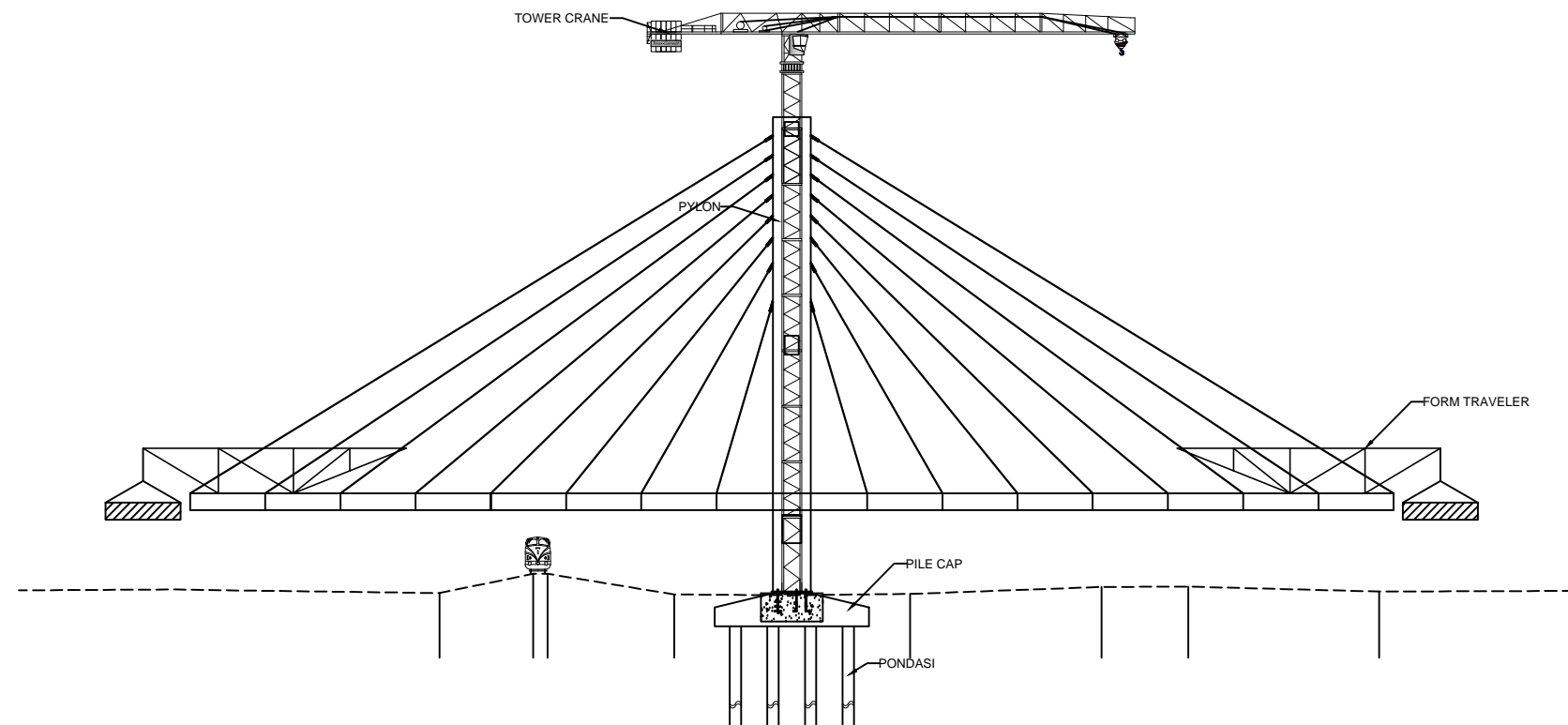
DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

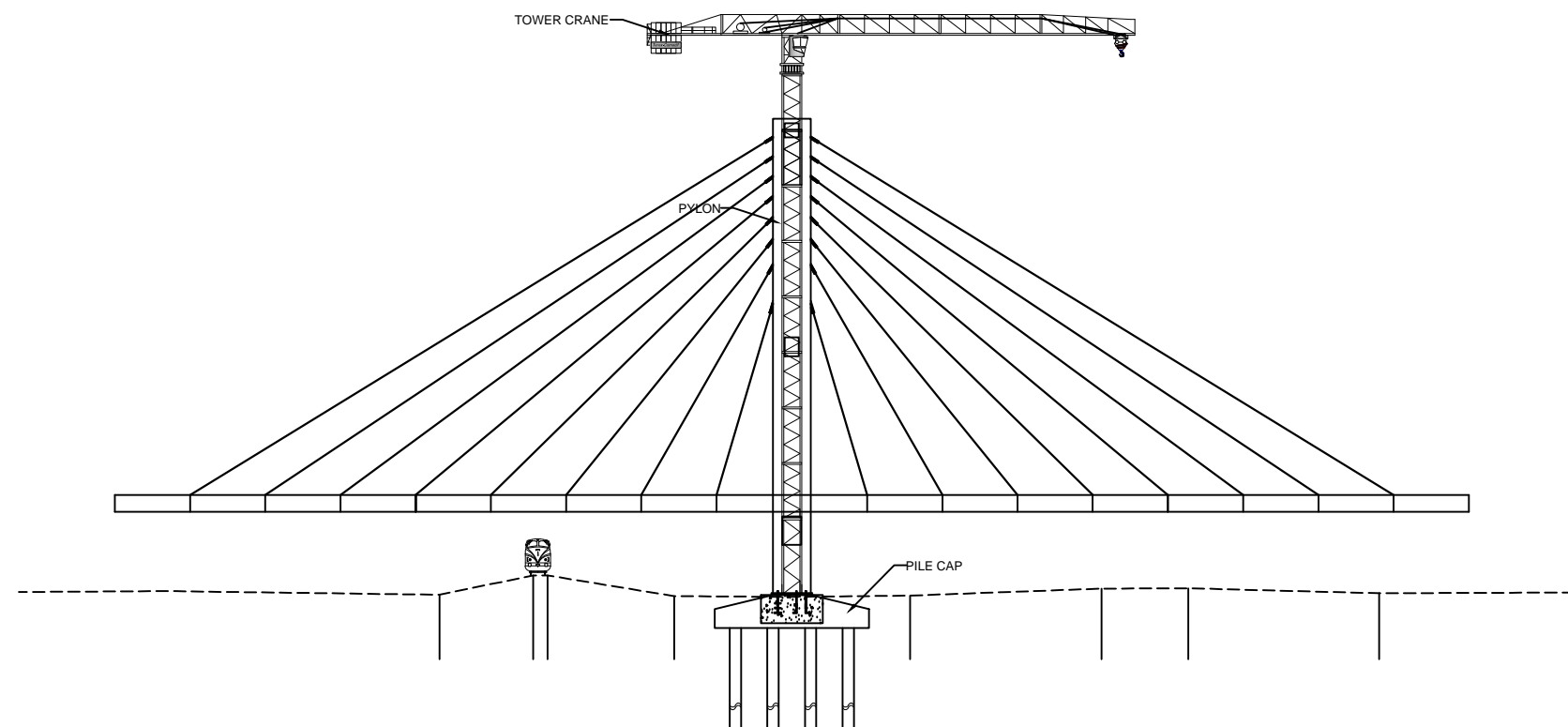
JUMLAH

29

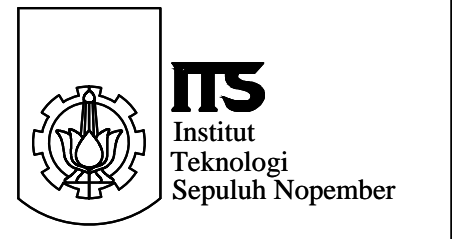
30



TAHAP 17: PEMASANGAN MG1
SKALA 1:750



HASIL AKHIR METODE PELAKSANAAN
SKALA 1:750



FAKULTAS VOKASI
DEPARTEMEN INFRASTRUKTUR SIPIL

JUDUL TUGAS AKHIR

MODIFIKASI PERENCANAAN STRUKTUR
JEMBATAN TOL PASURUAN-PROBOLINGGO
STA 29+325 DENGAN STRUKTUR
CABLE-STAYED BENTANG 144 METER

JUDUL GAMBAR

- TAHAP 17: PEMASANGAN MG1
- HASIL AKHIR METODE
PELAKSANAAN

NAMA MAHASISWA

IMAM NAKHROWI
NRP. 1011141 0000028

NAMA DOSEN

DOSEN PEMBIMBING I
Ir. IBNU PUDJI RAHARDJO, MS
NIP. 19600105 198603 1 003

DOSEN PEMBIMBING II
Ir. CHOMAEDHI, CES. Geo
NIP. 19550319 198403 1 001

NOMOR GAMBAR

JUMLAH

30

30

BIODATA PENULIS



Imam Nakhrowi atau yang biasa dipanggil sebagai Owi. Penulis dilahirkan di Brebes, 2 Desember 1996 dan merupakan seorang anak pertama dari dua bersaudara . Penulis telah menempuh pendidikan formal di SDN Sidokumpul 3 Gresik, SMPN 3 Gresik, SMAN 1 Gresik. Setelah lulus dari SMAN 1 Gresik pada tahun 2014, Penulis diterima di program studi Diploma IV Teknik Infrastruktur Sipil Institut Teknologi Sepuluh Nopember melalui jalur seleksi masuk ITS (SMITS) dengan NRP

10111410000028. Di jurusan ini, Penulis mengambil bidang studi transportasi. Penulis selama masa aktif kuliah aktif dalam kegiatan kemahasiswaan dan organisasi mahasiswa baik internal maupun eksternal kampus seperti FKMTSI Reg IX. Penulis sempat mengikuti Kerja Praktek di PT. Waskita Karya pada Proyek Pembangunan Tol Pasuran - Probolinggo. Penulis berharap Tugas Akhir ini mampu menyumbang perkembangan rekayasa transportasi dan bermanfaat bagi para pembaca. Apabila pembaca ingin berdiskusi dengan penulis, penulis dapat dihubungi melalui email : imamnakhrowi@rocketmail.com